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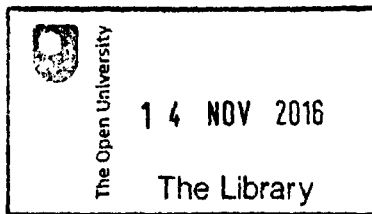
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Theory and Practice: An examination of the factors influencing the development of confidence in mathematical pedagogical content knowledge (PCK) within primary trainee teachers

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Dedication

This thesis is dedicated to beautiful Emily Caitlin-Rose who came along as a wonderful surprise in the middle of this study.

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Chapter 1 – Introduction

1.1 Aims of this study

This study explored, through a collective case study approach, the ways in which primary trainee teachers learn how to teach mathematics. It examined the experiences of trainee teachers following two different routes [See Appendix A for an overview of the key characteristics of each route] into qualified teacher status: Employment Based Initial Teacher Training (EBITT), and the Professional Graduate Certificate in Education (PgCE) route within the initial teacher training provider in which I undertake the role of Training Manager. A glossary of acronyms used within initial teacher training can be found in Appendix B.

1.2 Rationale

My initial rationale for this study focused around an interest in investigating the ways in which primary trainee teachers develop the knowledge and skills for effective teaching and learning, and how the practical (school-based training) and perceived theoretical (centre-based training) aspects of the course impact upon this development, and consequently levels of trainee confidence in teaching by the end of the training year. I initially envisaged this including a comparison of the two routes, with a view to exploring whether the structure of the training year, and the corresponding time allocated to aspects of school and centre-based training on each route had an overall impact on trainee development and confidence. The working title at this stage was, “Theory versus practice: Comparing two routes into Qualified Teacher Status”.

At an early stage it was decided that this initial proposal was too broad, and the focus was narrowed to an explicit focus on trainees’ pedagogical content knowledge (PCK) development. This aspect of teachers’ knowledge was outlined by Shulman (1986; 1987) in

relation to the ability of the teacher to transform the subject knowledge they possess into a pedagogical form which has been adapted to suit the needs and abilities of the children. This aspect was chosen as I wished to investigate how trainee teachers developed their repertoire of teaching and learning strategies and what informed their choices when personalising teaching in response to pupils' needs.

The area of mathematics was chosen as within the primary classroom it is considered to be an important core subject area, with daily lessons taking place across the full primary age range. It is also a subject in which teachers and schools are seen as being highly accountable, with schools being judged at the end of each key stage (children aged 7 and 11) through their results in mathematics. Additionally performance management targets for individual teachers often focus on the core subject areas, so teachers are anxious to ensure effective teaching and results.

Professional discussions with the course tutor for mathematics within the initial teacher training provider revealed that initial feedback from trainees during course induction often showed a low level of confidence in both subject knowledge and trainees' ability to teach mathematics. This anxiety about mathematics can be attributed to a trainee's own experiences as a pupil (Bibby, 2002; Brown et al, 2012; Henderson & Rodrigues, 2008). End of course evaluations (centre and school based training combined) at the outset of this study (2010-11), however indicated a high level of confidence in terms of the course 'preparing them to teach primary mathematics', with 89% of PgCE trainees, and 100% of the EBITT trainees rating the training as at least good. These statistics led me to question which particular aspects of the training year had impacted on this development.

Successive external evaluations of the Initial Teacher Training (ITT) course conducted by the Office for Standards in Education (Ofsted) had highlighted the mathematics element as being of high quality. During the course of this study in 2013, Ofsted stated that,

'The quality of training in mathematics is outstanding. As a result, nearly all trainees express confidence in teaching this subject. Their subject knowledge is developing well...Trainees' confidence and competence in teaching mathematics is enhanced further by the clear feedback they receive from the tutor team and school-based mentors.' (Ofsted, 2013: 8)

I wished therefore to investigate the nature of this training, what led to this rise in confidence level, and the role that both the centre-based training and the school setting played in this development.

Initially I also wished to consider whether either the theoretical or practical elements of the course had the greatest impact on the development of trainees' mathematical PCK. This was based on a simplistic model of theory referring to lectures that trainees attended at the centre base (known as centre-based training) and practice referring to the training that occurred within the school setting. The Becoming a Teacher study (Hobson et al, 2009) suggested that the amount of school-based training and the balance with theoretical elements was an important consideration when choosing an ITT route, with a high percentage of EBITT trainees valuing the opportunity to be trained by qualified teachers within a school setting. In the second year of my study however this focus was refined following my analysis of literature and the findings of my pilot study. These suggested that what was important was the inter-relationships between these two aspects of the course and the ways in which they combined to support and develop trainees' understanding and confidence within the classroom. I also broadened my perception of theory and practice, viewing them as elements that have the potential to take place within both the school and centre-based setting. My understanding of these aspects continued to be refined throughout my study and this is explored in Chapter 6 of this thesis.

The aim of this study was to identify and explore the key aspects of both courses that had a positive impact on the development of the trainees' confidence in mathematical PCK. This development was measured in terms of the trainees' perceived confidence level in the teaching of mathematics at key stages of the course. I acknowledged key differences in the amount of time allocated to the centre-based and school-based aspects of the two courses (See Appendix A). At the same time, the structural differences of each route enabled me to examine whether the balance of time and priority given to each aspect impacted on the trainees' development, including whether undertaking a greater amount of time in centre-based training impacted positively on trainees' confidence level in the classroom.

1.3 Organisational context

This was a collective case study of the Primary SCITT (School-centred initial teacher training) and EBITT (Employment based initial teacher training) Partnership, within which I undertake the role of Training Manager. The Partnership was formed in 1994 by a group of head teachers, to address recruitment issues in the local area. At the outset of this study the Partnership had a total allocation of 74 trainees, of whom 50 were following the EBITT route, and 24 were following a PgCE course, validated by the local university.

The links with the local university are strong, with 38% of the EBITT cohort at the outset of the study having completed their first degree with the university. The university offered a Bachelor of Arts (BA) (Honours) in Applied Education Studies, targeting local teaching assistants, who could undertake a 3-year degree part-time and remain working in local schools. This provided a clear career pathway from teaching assistant, to graduate, to trainee teacher. The consequence of this was that many of the trainees on the EBITT route (66% of 2010-11 cohort) had worked for several years in their supporting school, prior to enrolment on the course. This role of teaching assistant, nursery nurse or unqualified teacher, meant that many of the EBITT trainees were already fully immersed in the community of practice (Mutton et al, 2010, Wenger, 1998) of their supporting school.

The prior experience of trainees following the PgCE route differed in that the majority had not established a long-term relationship with a local school, with many only completing visits in a volunteer capacity prior to the start of the course. It could therefore be said that they had not been inducted into all aspects of school life, and that it was not until the autumn term that this immersion began.

As outlined in Appendix A, a key difference between the two courses was the time spent completing the elements of school and centre-based training. Centre-based training took place in a purpose-built building on the site of the Partnership's lead school, and took the form of lectures, seminars and practical workshops. The centre-based training was distinctive in that it utilised a range of primary practitioners from across its partners. This included teachers from local schools who had been identified as excellent practitioners, alongside local authority advisors who were experts in their fields.

1.4 Historical shift to school-based training

Appendix C provides an overview of the three main routes to qualified teacher status in the period covered by this thesis; a period of four years in which there was considerable change within initial teacher training.

Until the late 1990s initial teacher training within England and Wales, was dominated by higher education institutions (King, 2004). This was a model in which a university usually imparted knowledge and skills in teaching. Schools then provided the setting for the practice of these skills. In 1993, a new initiative in teacher training was introduced which enabled groups of schools to work collaboratively to offer teacher training and award QTS within the school setting, utilising their collective expertise. This shift in policy led to the formation of a number of school-centred initial teacher training providers (SCITTs). Following on from this the Graduate Teacher Programme (GTP) was set up by the Teacher Training Agency in

1997, with an aim to address the national shortage of teachers. This programme aimed to attract mature candidates to the profession through providing the opportunity to train within the school setting, whilst employed as an unqualified teacher. ITT providers offering this route were provided with an allocation from the Training and Development Agency and trainees were recruited onto the course and an employing school was assigned to them. The requirements of the route from 2000, were that GTs would be 'supernumerary' (an additional teacher within the class) and would work alongside an experienced class teacher for the duration of the training year, sharing an increasing amount of whole class responsibility. This supernumerary status ensured that time could be allocated to training activities both within the school setting (such as observation of good practice, research, team teaching, discussions with colleagues) and at the ITT provider's centre-base. For which the partnership forming this case study allocated 25 days.

This study began in 2011 and followed the publication of the government's White Paper 'The Importance of Teaching' (DfE, 2010), which signalled a further move of the focus of initial teacher training into schools. In 2013, the GT route ceased to exist and was replaced with the School Direct (Salaried) route (DfE, 2011). This new route enabled schools or groups of schools to apply directly to the National College for Teaching and Leadership (NCTL) for a trainee allocation, and working alongside an ITT provider, become more closely involved in the selection and training of trainees for their particular school setting. This approach was different in that the schools were able to determine the content and focus of the training programme based upon the specific needs of the trainee and the school. Alongside this there was an expectation that the school, or partnership of schools would employ the trainee, once they were qualified (NCTL, 2015). There was an additional NCTL requirement that 60 days during the year would be allocated to training, but there was no specification about the nature of this training, where it should take place and by whom.

In my professional role as Training Manager, I was interested in examining the role of theory and practice in initial teacher training in the context of a shift in policy towards a more school-based approach. If the future generation of teachers are to be trained in schools it is vital that it is ensured that the necessary skills, knowledge and understanding related to effective teaching and learning are developed. This study identified the ways in which these skills are developed in the context of mathematical PCK, and considered the roles that the ITT provider and the school had in this process, and how both worked effectively in partnership to advance trainees' knowledge, understanding and confidence in primary mathematics teaching.

I believe that that this study contributes important and new findings to the current body of knowledge related to initial teacher training, and to how trainee teachers develop their pedagogical skills in relation to the teaching of mathematics. Although other studies (Bennett, 1993; Buehl & Fives, 2009; Hanuscin et al, 2011; Monte-Sano, 2011; Rowland et al, 2009) have examined the ways in which trainee teachers develop teaching skills, including PCK, this study is unique in that it focuses solely on the area of primary mathematics and on the developmental experiences in terms of PCK of trainees from within two different routes into qualified teacher status. As outlined above this study was undertaken during a time of considerable change within ITT and straddled the transition period in which the School Direct route into qualified teacher status was introduced and embraced by schools and training providers. I believe that the findings and recommendations of this study are transferable and very relevant within this new and evolving landscape of teacher training. I would argue that a consideration of the importance of theory alongside practice is particularly important in light of this potential shift towards teacher training taking place predominantly within the school setting. It is vital that the mutually beneficial relationship between theory and practice, which is explored within this study is maintained, in order that the future generation of primary mathematics teachers are

able to develop skills, knowledge, understanding and confidence, enabling them to be effective within their current setting and beyond.

1.5 My professional journey

Professionally I have been a primary teacher for 22 years and a teacher educator for 20 of these years. My experiences of mathematics have always been positive. As a child I experienced great success and enjoyment during mathematics lessons. Although the teaching approach was always very textbook focused – it was an area of the curriculum that I understood with relative ease and I relished the challenge of solving more difficult problems and gaining that all important tick in my book. This led to me continuing my studies up to A-level. I qualified as a primary school teacher in 1992, gaining a Bachelor in Education. A love of mathematics was an aspect that I wanted to promote within my teaching from an early stage, alongside a desire to enable children who were struggling to gain understanding and that feeling of success. Within my early teaching career I experienced first-hand immense changes to the approach to the teaching of mathematics. The advent of the National Numeracy Strategy in 1999, led to a shift away from text books towards an approach in which the children, alongside their peers and the teacher, became active participants in their own learning – engaging in problem solving, mental calculations and investigations. As a teacher this encouraged me to reflect upon and develop my pedagogical approaches. I aimed to facilitate learning in mathematics in an engaging way, whilst meeting the particular needs of all the children, and ensuring that they were able to apply the knowledge they gained within meaningful real-life contexts. I always had a keen interest in supporting the needs of the children who found mathematics challenging – striving to find different strategies and explanations that would lead to their understanding

My interest in the role of teacher educator emerged at an early stage of my teaching career, firstly as a teacher supporting a trainee within my class, then as a school-based mentor and for the last 10 years as tutor and Training Manager. For a number of years I fulfilled a dual

role supporting and developing trainees both within the school and centre-based setting on the PgCE route. This allowed me to reflect upon the inter-relationship between the two elements, gaining an insight into the importance of both. My particular interest in the role of mentoring in supporting teachers during the training year and beyond, led to my undertaking of a masters degree. Six years ago I became a full-time teacher educator and began to oversee trainees on both the EBITT and PgCE routes. As a part of my professional responsibility to strive to develop good and outstanding teachers, I began to consider the differences between the two courses and to question the ways in which each route effectively prepared trainees for their role as a teacher. My undertaking of this doctoral study has enabled me to consider this in the context of mathematics.

1.6 Research questions

The rationale for undertaking this study has led to the formation of the key research question:

How do primary initial teacher training trainees develop their mathematical pedagogical content knowledge (PCK) during the training year?

From this key question, the following lines of enquiry have been defined:

[See Appendix B for definitions of school-based and centre-based training]

- What is the role of the school, and school-based training, in developing trainees' mathematical PCK?
- What is the role of centre-based training in developing trainees' mathematical PCK?
- To what extent is centre and school-based training interlinked in supporting the development of mathematical PCK?
- Which elements of the training year do trainees perceive to have the greatest impact on the development of their confidence in mathematical PCK?

A mixed method approach was utilised including: questionnaires, group interviews, scrutiny of lesson observation reports and an observation of a centre-based mathematics session.

The justification for this methodological approach has been provided in Chapter 3. As well as information from the trainee cohort, additional perspectives have been gained from school-based mentors and the ITT provider's mathematics tutor.

1.7 Chapter overview

Chapter 2 provides an overview of the key literature engaged with during the formation of the theoretical framework. This includes a consideration of:

- Definitions of theory and practice
- How trainees learn
- Nature of pedagogical content knowledge
- Influence of the school context, including the role of the mentor and observation of good practice
- Role of reflective practice

Chapter 3 outlines the methodology of this study including:

- Formation of lines of enquiry and rationale for the research methods
- Ethical considerations including power relationships and insider research
- Data analysis process

Chapter 4 focuses on the impact of the school context and considers:

- Support structure
- Observations of good practice
- Lesson observation feedback and target setting
- Supporting pupil progress
- Reflective practice
- Impact of the second school experience

Chapter 5 considers the impact of centre-based training including:

- Development of teaching and learning strategies
- Resources

- Subject knowledge development
- The wider picture – understanding pupil development
- Support for the reflective process

Chapter 6 discusses theory and practice including:

- An examination of trainees' perceptions of each aspect
- Impact of each on trainee development
- Whether there is an ideal balance

Chapter 7 provides an overview of conclusions in relation to the research question and each line of enquiry, including:

- Recommendations for practice and further research
- Unique contribution to existing body of knowledge
- Critical reflections on limitations of this study

1.8 Summary

This chapter has provided the rationale for this study and has outlined the organisational context in which it is set. Changes to the national initial teacher training educational context have been outlined and the ways in which this could impact on trainee development have been identified. The research questions and lines of enquiry have been outlined. Chapter 2 will now outline the theoretical framework on which this study is based.

Chapter 2 - Literature Review

This chapter provides an overview of the key literature engaged with during the formation of the theoretical framework of this study, and how this literature informed my lines of enquiry. Key aspects include: definitions of theory and practice, how trainees learn, nature of pedagogical content knowledge, influence of the school context and the role of reflective practice.

2.1 What is theory?

Theory can be viewed as the provision of professional knowledge about the craft of teaching (Hagger & McIntyre, 2006; Smith & Hodson, 2010), and all elements of training that take place outside of the school and classroom environment (Hobson, 2003). The location of this training varies across initial teacher training providers, but includes university campuses, purpose-built training centres or classrooms within schools allocated for this purpose. The format of this training can also vary, but usually includes lectures, small-group seminars, practical workshops and tutorials. Discussions and debates with others outside of the school setting can provide trainees with opportunities to share experiences and theories, so enabling the process of self-reflection (Furlong et al, 2000, Loughran & Russell, 1997). Edwards and Protheroe (2003) discuss the need for trainees to work at two levels – generality and specificity. This generality of knowing, they believe, will enable trainees to, 'interpret new teaching situations and see the pedagogic potential in them' (2003: 232). Data in this study indicated that this was where centre-based training came to the fore, as it offered an opportunity to consider aspects of teaching and learning in general terms and also share ideas from a range of trainees across a variety of contexts and age phases. This was viewed as beneficial as it expanded upon often heavily socially situated knowledge that trainees gain from classroom experiences (Philpott, 2006). Alexander (2009) noted however that the teaching of pedagogical knowledge is often very limited, leading to teachers

operating within the classroom without true understanding of what they are doing. The extent to which this was the case within this study is explored within Section 5.2.

It would be wrong however to assume that theory is only generated outside of the school and classroom setting. Subject leaders and mentors could be perceived to be exploring the theory around the pedagogy of teaching and learning through their observation feedback and discussions with trainees (Mutton & Butcher, 2008). Some researchers though have argued that often these conversations do not focus on developing an in-depth understanding of why things are so or happen, but merely touch upon the surface (Borko & Mayfield, 1995; Edwards & Protheroe, 2003; Mutton et al, 2010). This could be as a result of time constraints within meetings, a lack of in-depth understanding of the concept themselves on the part of the mentor or subject leader, or an inability to explain a process that the experienced practitioner now does innately (Edwards & Collison, 1996).

Data gained from interviews and questionnaires indicated that for many trainees the model in which theory is gained outside of the school setting and then applied and reflected upon back in the school setting is most effective. Within the classroom as both teacher and observer the trainee is able to make sense of the theory gained (Pinder, 2008). Trainees are able to see and apply the theory in action, and reflect upon its impact on learners. However it should be recognised that for many trainees, reflections in the initial stages may need to be guided and supported by a more experienced practitioner – with discussions being an important aspect (Pinder, 2008). Additionally, the transference of learning from theory to practice can be problematic if the relevance of the theoretical training to the classroom setting is not clear or does not reflect what is actually taking place within the school setting the trainee enters – there is a disparity between the ideal of theory and the reality of the classroom (Philpott, 2006; Russell, 1988). Hobson et al (2009) found that this was usually not the case with school-centred initial teacher training (SCITT) routes, and could be due to stronger connections made with current primary practitioners, who often lead lectures on the

course. This was an important consideration in my study as it is a SCITT route, and the mathematics sessions are led by a practising primary teacher. The value of this is outlined in Section 5.1.

Trainee teachers are not a homogenous group, however Hobson (2003) suggests that they can be categorised according to the value they place on the perceived theoretical elements of training:

- The proceduralist apprentice seeks only information about what to do within the classroom in order to be successful, and has little or no desire to develop deeper understanding behind the rationale of their actions.
- Understanding-oriented learners wish to gain a wide repertoire of teaching strategies but alongside this display a desire to develop a critical understanding of educational practices, including why things are effective or not for particular groups of children. They place fairly equal importance on gaining both theoretical and practical knowledge.
- The education-oriented apprentice lies between the other two categories. They value highly the opportunity to develop a repertoire of teaching strategies for use within the classroom, but also see the value of developing some theoretical background knowledge. However this is only seen as supporting their work within the classroom, which is where they believe most of their learning takes place.

Hobson's model was considered when drawing conclusions about how trainees viewed theory at different stages of the training year (See Section 6.4)

2.2 What is practice?

Practice can be viewed as the elements of teaching that take place in the classroom, alongside aspects of the role such as planning and assessment which directly support this work. Research (Hagger et al, 2008; Hobson, 2003; Mutton et al, 2010; Smith & McLay,

2007) suggests that trainees very often value the practical elements of the training year more highly than other components and feel that this is when they learn the most. They believe that they learn effectively when they are presented with the challenge of experimenting with teaching for themselves - often seeing it as a process of learning by trial and error (Furlong et al, 2000; Hobson, 2003). Hagger and McIntyre (2006) refer to this process as practical theorizing in which trainees attempt to make sense of and find answers to the challenges they face in the classroom. These answers can be found through authoritative advice from a mentor, tutor or colleague, or may be discovered independently through the critical examination of continued trial and error. In the early stages theorizing could occur as a result of observation of good practice, when trainees consider how what they observe can be applied to their own situation (Zanting et al, 2003). Reflection can therefore be seen as a key part of developing practice, with trainees drawing upon other elements of their learning both from the past and during the training year, in order to develop their confidence within the classroom. These elements are explored individually in Section 2.4.

There has been some criticism of the ways in which some trainees learn within the classroom. In the initial stages of the training year trainees are often seen to revert to a mimicking approach – in which they replicate the actions and mannerisms of the class teacher they are working alongside - relying heavily on strategies which they have seen to be successful: a 'bag of tricks approach' (Britzman, 2003; Buitink, 2009; Edwards & Collison, 1996; Loughran, 1997; Loughran & Russell, 1997). The trainee goes through the mechanisms of teaching, potentially with some degree of success, but with no thought or real understanding of why things are so. I would argue however that it is unfair to reject this approach when a trainee is entering the early stages of becoming a teacher. Trainees are often all consumed by the fear and anxiety of standing in front of the class (Britzman, 2003, Fuller & Brown, 1975) and it is therefore understandable for them to seek support from the application of the already proven successful pedagogy of the current class teacher. It could

be argued that until a trainee enters the latter stages with concerns, 'about pupils, their learning, their social and emotional needs, and about relating to pupils as individuals' (Fuller & Brown, 1975: 39), they will be unable to fully engage with reflective practice, and generalised aspects of learning outside of the school context. Instead the concern should focus on trainees who are unable to demonstrate their own pedagogy with understanding at later stages of their development.

2.3 Examination of pedagogical content knowledge

The term pedagogical content knowledge was first used by Shulman (1986; 1987) when he defined the seven categories of knowledge and understanding that a teacher needs in order to be effective. Within the model three categories of content knowledge are identified:

Subject matter content knowledge (SMK) – the subject knowledge per se which the teacher possesses and their depth of understanding of both what and why something is so.

Pedagogical content knowledge (PCK) – This is seen as identifying, 'the ways of representing the subject which makes it comprehensible to others.' (Shulman, 1986: 9) This focuses on the ability of the teacher to transform the content knowledge they possess as an adult into a pedagogical form adapted to suit the needs and abilities of the children they are teaching. This knowledge requires awareness and understanding of the common difficulties within specific topics, including preconceptions and misconceptions, and how these may be addressed to enable learning.

Curricular knowledge – this encompasses the knowledge of the range of relevant materials and tools that the teacher can draw upon to teach at a given level.

Critics of Shulman (Mason & Spence, 1999) suggest that the model is at fault as it is static, suggesting that elements of PCK could be learned away from the classroom context. It is argued that teaching cannot be a pre-determined set of interventions, and that teachers have to develop the ability of 'knowing-to-act in the moment' (Mason & Spence, 1999: 136).

An important element of this is the teacher's ability to reflect on pupils' responses, both during and after the event, and then respond in their actions. The development of reflective practice is considered in more detail in Section 2.7. Although the reflective responses that are necessary within a lesson cannot be truly pre-determined, teachers develop a repertoire of responses that they draw upon. With trainee teachers it should be noted that it is likely that this repertoire will be limited, especially at the beginning of the training year, and this may impact on confidence levels.

Fennema and Franke (1992) develop Shulman's model, suggesting that teachers' knowledge is more interactive and dynamic – emerging from interactions with pupils within the context of the classroom. This model highlights the key aspects of: knowledge of content, knowledge of pedagogy, knowledge of students' cognition and the teacher's beliefs. It is suggested (Fennema and Franke, 1992) that within the classroom the teacher's knowledge of the content combines with the other three elements to determine the teacher's behaviour and subsequent teaching practices. This knowledge is dynamic as it changes and evolves as the teacher interacts with both the subject matter and the pupils.

Responding to this belief (Fennema & Franke, 1992) that mathematical knowledge emerges within the classroom, Rowland et al (2005) categorised four interlinked aspects of teacher knowledge which arise from situations within the classroom. These referred to as The Knowledge Quartet (KQ), consisted of the dimensions of: foundation, transformation, connection and contingency. Pedagogical content knowledge was highlighted as a key component of the transformation dimension, as it enables the teacher to make decisions about the strategies to use in order for children to learn. The experience of working alongside children and the resulting reflective deliberations in relation to the key aspects of this quartet were seen to change trainee teachers' thinking and practice about mathematics teaching (Turner, 2012).

Within this Knowledge Quartet, a key distinction is also made between the commonplace knowledge that everyone holds, and the body of pedagogical knowledge, which it is important for teachers (Rowland et al, 2009). The dimension of contingency recognises that there are events which a teacher is unable to plan for, and which will require them to respond in-action.

Bednarz & Proulz (2009) support the notion that mathematics teaching can be unpredictable and that, teachers' actions emerge and require them to be able to react in the moment. They suggest that mathematical knowledge needs to be situated, and linked to the children and the spontaneous contributions they generate. In order for the teacher's response to be effective it has to be interpreted within the particular learning context. Teachers refine their existing knowledge when the same activity is conducted with a different group. It could be questioned however whether this refinement is of a constant nature, or whether teachers reach a point where they are not inventing responses anew but merely drawing upon previous experiences.

Additionally Petrou & Goulding (2011) suggest that context can define the different components of mathematical teaching. This can be on both a local (school or local education authority) and a wide scale (country) aspect. The education system, the educational aims and beliefs, the curriculum, the materials that are available and the assessment system can determine the particular pedagogical approach that exists.

Research (Ball & Bass, 2002; Goulding et al, 2002; Mason & Spence, 1999) suggests that PCK cannot be separated from content knowledge, as teachers need to utilise both their mathematical and pedagogical knowledge when making choices within the classroom. Often when dealing with the unexpected, teachers are required to make sense of methods and solutions different from their own – this will require a certain level of mathematical knowledge and reasoning.

In Ball et al (2005), elaborated upon Shulman's work providing a model for mathematical knowledge for teaching. This focused on the specialist content knowledge of mathematics which moves beyond simply knowing the content of what is to be taught. This knowledge considers the skills that teachers deploy as they teach, and the aspects of mathematical knowledge and skills teachers need in order to teach effectively. Within this model (Ball et al, 2008) PCK is linked specifically to the constructs of:

- **Knowledge of Content and Students (KCS)** – The ability of the teacher to anticipate difficulties and misconceptions that may arise within particular areas of mathematics, and how to subsequently hear and respond appropriately, both in planning and teaching, in order to take forward pupils' learning. Additionally this knowledge allows teachers to choose appropriate examples and representations within their teaching.
- **Knowledge of Content and Teaching (KCT)** – This relates to the decisions that teachers make in relation to the sequence of activities within the teaching sequence. Within this knowledge there is the understanding of why some representations are better for some pupils than others. Within the act of teaching, this aspect will influence decisions in relation to when it is advantageous to pause or clarify particular teaching points.

Within this model there is the belief that a teacher may draw upon different forms of knowledge depending on the type of situation they are responding to. This may be theoretical – related to specialized knowledge that teachers possess about mathematical understanding and reasoning in teaching. Alternatively teachers' knowledge may be based in practice and gained from the previous mathematical experiences with pupils.

At the same time, Petrou and Goulding (2011) highlight that this conceptualisation of mathematical knowledge for teaching does not acknowledge the importance of teachers' beliefs in mathematics teaching (Goulding et al, 2002). If a teacher sees mathematics as solely a set of rules and routines then they may be constrained when they have to deal with unexpected situations within the classroom, leading to a potential impact on pupils' learning.

Within my literature review I considered Shulman's model of PCK and also its critiques. My intention was not to prove or disprove Shulman's perspective but to consider how the different elements of the training year enable trainees to develop their mathematical PCK knowledge. This literature review highlighted some commonality in key components of pedagogical knowledge, and allowed me to formulate a definition of PCK which was utilised in this study:

- Awareness of the common misconceptions the children may encounter linked to the topic being taught;
- Understanding of how to deal effectively with these misconceptions either as part of the planning and/or assessment process, or in-action in response to pupils' emerging needs;
- Understanding of the ways in which children learn mathematics, and the teaching strategies and resources teachers can utilise within this process;
- Awareness of pupil progression within the topic area to be taught, including the fundamental building blocks which support pupils' progression to the next level of attainment;
- Understanding of, and an ability to execute, the fundamental key components of effective teaching and learning, including: the role of assessment in the planning and teaching process; role of modelling in the teaching process; effective differentiation, and creation of an engaging curriculum.

This study considered how mathematical PCK emerged within practice and the ways in which theory enabled and enhanced the trainees' understanding. Links to reflective practice in-action were also made. It was important therefore to consider the ways in which trainees learn.

2.4 How trainees learn

This section will examine the ways in which trainee teachers learn, and the factors that can either help or hinder this development.

2.4.1 Influence of previous school experiences

Previous school experiences are perceived to have a great impact on trainees' perceptions of teaching and learning (Borko & Mayfield, 1995; Britzman, 2003; Edwards & Collison, 1996; Feiman-Nemser, 2003; Lortie, 1975; Mutton et al, 2010; Nicol, 1997). These experiences refer to the time everyone has spent as a pupil during their childhood, with Edwards and Collison (1996) suggesting that these memories often relate to primary schooling. This is linked to the ideal of a nurturing environment often associated with the perception of primary schooling – an image that many trainees wish to emulate. It could be questioned whether and why primary schooling has such an impact, as this is most distant in the past and is from the perspective of a child and a learner, rather than from that of a teacher and a facilitator of learning (Britzman, 2003; Edwards and Collison, 1996). Researchers have found that trainees often revert back to the ways in which they learnt mathematics (Mutton et al, 2010), particularly in the early stages of training, when experiencing anxiety or when having to respond to a contingency (Rowland et al, 2005) following an unexpected pupil response. The limited time on a one-year postgraduate course can also mean that primary trainees have little opportunity to develop their subject matter content knowledge, leading them to rely on knowledge gained often much earlier from their own schooling (Askew et al, 1997; Williams, 2008).

Additionally research suggests that it is the role of teacher training to encourage trainees to both view and teach in ways which are fundamentally different from how they were taught (Borko & Mayfield, 1995; Nicol, 1997). Feiman-Nemser (2003: 4) refers to these images and beliefs as 'filters', which may, 'also function as barriers to change by limiting the ideas that teacher education students are able and willing to entertain.' At the same time, it is also important to consider whether positive influences can be taken from these previous experiences, however limited they may be, and that it would be wrong to discount the ways we were taught as pupils as being no longer relevant or correct.

2.4.2 Mathematical anxiety amongst primary trainees

Research (Brown et al, 2012; Goulding et al, 2002; Henderson & Rodrigues, 2008; Ma, 1999; Williams, 2008) highlights the inter-relationship between teachers' confidence levels, and their ability to teach mathematics competently and effectively, so enabling pupils' learning. Mathematics is often a subject area which trainees feel anxious about (Borko & Mayfield, 1995; Britzman, 2003; Edwards & Collison, 1996; Feiman-Nemser, 2003; Lortie, 1975; Mutton et al, 2010; Nicol, 1997) largely as a result of the experiences that they encountered as a child, including feelings of failure or embarrassment due to the more formal, rote learning and text book approach of mathematics teaching in the past. These experiences could be seen as having potentially a negative impact on the trainee's teaching and the pupils' subsequent learning. Teachers with more positive attitudes towards mathematics have been found to be more inclined to take risks and engage with more effective inquiry-based approaches to learning, (Wilkins, 2008) and display a confidence to identify and tackle pupils' difficulties (Goulding et al, 2002). Teachers lacking confidence may shy away from these opportunities and so impact upon pupils' learning. At the same time, research has shown that teachers who lack confidence may be more attentive to the planning and preparation of lessons (Goulding et al, 2002), and draw upon their own negative experiences of learning mathematics as a child to ensure that they teach differently

and make mathematics enjoyable and accessible to all abilities of children (Askew et al, 1997; Bibby, 2002; Brown et al, 2012).

Particular aspects of initial teacher training have been identified as having a positive impact on trainees' anxiety levels (Brown et al, 2012). Opportunities to observe good practice, repeated opportunities to engage in the teaching and reflection cycle, and ensuring a high level of preparedness with the subject matter to be taught, were seen to increase trainees' confidence levels. Trainees benefit from lessons in which their effective teaching brings about a high level of pupils' understanding, as this provides them with a sense of personal achievement too.

2.5 Influence of the school context

The school context in which the trainee teacher completes their training is also seen (Edwards & Protheroe, 2003; Mutton et al, 2010) to have a major influence on learning and development, as it is where they are immersed in the planning, teaching and assessment cycle. Trainees enter into, and join a community of practice (Mutton et al, 2010, Lave & Wenger, 1991), and once there the routine, practices and expectations of the specific school will have an enormous influence on the construction of the trainee's identity as a member of the community: first as a trainee and then as a teacher.

My professional observation was that many EBITT trainees are already fully embedded within the ethos of their school before the course starts, as they have often fulfilled a teaching assistant role for over a year prior to starting teacher training. EBITT trainees are often in a better position as they do not need to spend time familiarising themselves with the demands of the school context. At the same time it could be argued that as the school was offering financial support (In 2014-15 schools were expected to contribute £10,500 towards training) the trainee will feel particularly obliged to follow without question the expectations of the community they are entering. For PgCE trainees it is important that information about the

school context they are entering is quickly assimilated, so that they are able to perform successfully within the environment in which they have been placed.

At the same time potential issues with a trainee remaining within an environment in which they are already fully immersed should also be acknowledged. It could be argued that they may be unable, or unwilling to examine practices with a critical eye, as they are embedded in the culture of the school. This could lead to them accepting ineffective practices, through either lack of awareness of good practice, or concerns over damaging existing relationships.

Research (Edwards & Protheroe, 2003; Hascher et al, 2004 Loughran & Russell, 1997) suggests that often context specific learning cannot be easily transferred and applied into a new situation. This could be particularly problematic for PgCE trainees who are less likely to be employed as NQTs within a school in which they have completed a teaching practice. However this may be less of an issue for EBITT trainees who often maintain their employment in the same school once they are qualified (In 2014, 56% of EBITT trainees within the provider gained employment in their base school, compared with 32% of PgCEs). Conversely as the PgCE training year provides more opportunities for trainees to experience a range of school contexts (See Appendix A) they may become more adept at adapting, and more aware of the subtle differences, of school contexts. Hagger et al (2008) question whether ITT programmes can fully equip trainees to teach within a range of contexts. This study investigated whether there was evidence of transference of context specific learning, including a focus on the impact of a contrasting second school experience.

Whilst in school, trainees have to fulfil a dual role which they often find problematic; having to conform to the ideals of the school and also demonstrate the requirements of an effective teacher as indicated in the Qualified Teacher Standards (Hodkinson & Hodkinson, 1999). Trainees may never feel that they have the full responsibility and ownership of the class they are placed within (Mutton et al, 2010), and this could result in them shying away from the

implementation of ideas introduced during centre-based training, or avoiding taking risks (Beck & Kosnik, 2000).

The trainee themselves can have a great influence over whether they are able to continue to learn in new and diverse contexts, once they have completed teacher training (Hagger et al, 2008). Buitink (2009) identified two approaches to learning - passive and active. The passive learner is seen as only being concerned with the mastering of skills and knowledge that will allow them to function within the moment – they have no desire for long-term learning. An active learner is able to set themselves more far-reaching objectives, and will be proactive in seeking feedback from others, and engaging in reflective practice. This active approach, which should be supported by the mentor, will enable the trainee to become a life-long learner. Connections could be made with Hobson's (2003) model of learners (See Section 2.1), with trainees who are passive learners displaying a proceduralist apprentice approach, and active learners more readily engaging with both the theoretical and practical aspects of learning.

2.6 Role of the mentor

Mentoring can be defined as the one-to-one support of a trainee teacher by a more experienced practitioner, with the aim of assisting the development of the trainee's expertise and to facilitate their induction into both the culture of the teaching profession as a whole and the specific context of the school in which they are working (Malderez & Bodoczky, 1999). To enable this development and induct the trainee into the community of practice (Lave & Wenger, 1991; Wenger, 1998) of both teaching and the specific school context the trainee is working within, the mentor can be seen to take on a number of roles. That of modeller of good practice (Hobson, 2012); facilitator of opportunities (Malderez et al, 2007); provider of psychological support (Hobson, 2009); assessor and challenger of practice (Daloz, 1986; Tang, 2003), and guider of reflection (Beck & Kosnik, 2000; Gut et al, 2014; Malderez & Bodoczky, 1999). It is necessary for the mentoring role to be fluid, flexible, and responsive

to the trainee's needs, which will change and develop through the training year (Fuller and Brown, 1975; Furlong and Maynard, 1995; Russell, 1988), as they move from a focus on their own anxieties and performance in the new role of teacher, to that of a facilitator of pupils' learning. Alongside this there is a need to provide an appropriate balance between support and challenge (Daloz, 1986; Malderez & Bodoczky, 1999; Tang, 2003), so enabling the trainee to develop both their classroom and reflective practice.

Mentors fulfil a crucial role (Edwards & Collison, 1996; Mutton et al, 2010; Strong & Baron, 2004) in terms of the advice and feedback they provide on teaching. Their discussions centred round the principles of practice play an important role in developing the trainee as a reflective practitioner.

Research focusing on observation feedback, (Borko & Mayfield, 1995; Edwards & Protheroe, 2003; Mutton et al, 2010) suggests that mentors do not always enable trainees to develop higher levels of thinking about teaching and learning. This is due to the nature of the feedback given. Edwards and Protheroe (2003: 229) found that "79% of feedback talk focused simply on descriptions of observed events ... reiteration of observed practice and general encouragement." In order for higher level thinking to take place mentors need to not just offer support and answers, but use higher order questioning to provoke thought and encourage trainees to find their own solutions to challenges (Mutton et al, 2010).

Furthermore Borko and Mayfield (1995) found that general pedagogical issues were frequently addressed in trainee/mentor conferences, but discussions specifically related to mathematics specific pedagogy were, 'generally brief and superficial, did not delve into the nature of the mathematics and did not focus on strategies for presenting particular topics to students.' (Borko & Mayfield, 1995: 510) For higher-level subject specific learning and development to take place in mathematics, high quality mentoring must be in place. This led to my decision to undertake an analysis of lesson observation forms as a methodological

aspect of my study, including a consideration of the depth of mentor feedback in terms of specific aspects of PCK. It could be argued that this was an important consideration in the primary school setting where mentors were expected to offer feedback on the full range of subjects.

The best model for trainee professional development could be viewed as one of engagement (Tang, 2003), where challenge and support is provided by the whole school community, with trainees being able to take the initiative in engaging in productive learning opportunities with a range of people within the school. Mentoring could therefore describe the process by which any person within the school-based setting offers support to the trainee. This draws upon a range of expertise and perspectives, so allowing the trainee's experiences and development to move away from the specificity of just one teacher and class. It should however be questioned whether the mentor is able to offer support beyond their own ideologies of teaching and the context of the school. It was important to consider whether mentors had developed their own generality of learning, or are constrained by the expectations of the school ethos.

2.7 Role of reflective practice

The value of engaging in reflective practice when learning to teach is widely advocated (Hagger et al, 2008; Loughran, 1997; Moon, 2004). This is based on the belief that long-lasting and meaningful development will only occur if the trainee is active in their own learning. This includes the decision-making process that occurs as they move from one teaching activity to another, both within and between lessons. For progress to be made, a trainee must be open to self-criticism of their own practice (Russell, 1988), however in the early developmental stages trainees may find this challenging as they are not yet able to understand why things occur and suggest solutions. McIntyre, (1993), suggests that reflection is more important for experienced teachers as beginner teachers have very limited experience to draw upon in order to develop their practice, and must instead utilise ideas

from a variety of sources, including their mentors. At the same time, in the latter stages of the training year trainees may be able to engage in reflective practice in greater depth as a result of the knowledge they have gained from discussions and training within the school and centre-based setting.

Schön (1987) originated the terms reflection on-action and reflection in-action to distinguish the situations in which reflective practice occurs.

On-action refers to the process that takes place following the lesson in which the trainee steps back and considers the key elements of the lesson: what went well and why, what didn't go well and why, and the implications for future practice. Trainees engage with this through the completion of formal lesson evaluations; within well-managed lesson feedback discussions; when planning for the next lesson and informally in their own minds whilst their thoughts go back over the lesson.

In-action is defined as the reflection that takes place as the lesson unfolds. This higher order reflection allows the teacher to alter the course of the lesson in light of children's responses and learning. It could be argued that for a trainee to be able to engage in this form of reflection in-action they must have the confidence to do so, the ability to understand intuitively what is happening in the lesson and the needs of the pupils, and have a repertoire of appropriate responses. Within mathematics, teachers need to be able to readily utilise their skills in-action as pupils may respond in variety of ways to a problem that requires a precise correct answer. Teachers are required to evaluate the pupil's reasoning and if necessary support them to overcome any misconceptions. Mason and Spence (1999) categorised this as knowing-to act in the moment. For this to occur the teacher requires both accumulated relevant teaching knowledge to come to the fore and to have awareness that action is necessary. They suggest that this is unlikely to occur without intentional preparation on the part of the teacher, including the collation of a range of alternative

actions. This could be gained through the theoretical elements of the course, or observations and discussions as part of practice. This re-iterates the unlikelihood of this type of reflection occurring within the early stages of the training year. Furthermore, (Eraut, 1995) highlights that in-action teachers have very little time to reflect and that they often have to respond in the spur of the moment with very little, if any, in-depth thought.

This study considered the ways and depth in which trainees reflect, and identified the stage of the training year when the in-action reflections developed. The role of both theory and school-based practitioners in supporting this process was considered.

2.8 Summary

This chapter has considered definitions of theory and practice and highlighted how theory can be gained both within centre-based training and within the school setting. This study considered the impact each aspect had on the development of mathematical PCK and the extent to which theory was taken account of and developed within the school setting. In Chapter 6 the inter-relationships between theory and practice is examined in detail, including an exploration of the value that trainees placed on the theoretical and practical of the course at different stages of the training year. Whether both are vital in ensuring that a trainee develops a depth of understanding and confidence in the teaching of mathematics was examined. This relationship between the theoretical elements of the course can be viewed as symbiotic with each enhancing the other.

The important role of the mentor has been outlined, including their potential in supporting the development of mathematical PCK through discussions and observations. The effectiveness of this role and the support that other practitioners within the school provide is examined within Section 4.1.

The role of reflective practice has been identified and is examined further in Chapters 4 and 5 in relation to the trainees' stage of development. The impact of reflective practice on the development of mathematical PCK was explored, including a consideration of whether trainees are able to reflect in-action and in-depth, or whether their reflections are purely responses to events with little underlying drawing upon theory.

This literature review influenced the research design in that it provided a framework for the initial questionnaire element of this study, and identified the potential key aspects affecting the development of trainees' mathematical PCK. My methodological processes will now be outlined.

Chapter 3 – Methodology

This chapter provides an overview of the methodological processes and considerations that took place in this study. It outlines the reasoning behind the choices that were made, linking this to the review of literature that was undertaken. Additionally it highlights the ways in which the research questions were shaped and refined, and how the research tools were modified in light of ongoing reflections and the pilot study in year one. Finally this chapter outlines the methods, by which data were analysed, and how this led to the formation of the key themes and ideas in relation to how primary trainee teachers develop their mathematical pedagogical content knowledge (PCK). This data is then examined in-depth in Chapters 5 and 6.

3.1 The aim of the study

This study examined the ways in which primary trainee teachers developed their mathematical PCK, and identified and explored the key aspects of the training year that had an impact on this development. This development was measured in terms of the trainees' perceived confidence level in the teaching of mathematics at key stages of the training year. The decision was made to focus on measuring confidence levels rather than trainee attainment as I had identified through literature and informal discussions with trainees in previous years, as part of my training manager role, that mathematics was often a subject area in which trainees enter the training year with a low confidence level and anxiety about the subject and teaching it.

In order to achieve this aim I utilised a mixed methods approach, with both quantitative and qualitative data being gathered. I wished to explore in-depth the stories behind the trainee teachers' journeys through the training year, and what they perceived to be the determining aspects of their development. A mainly qualitative approach was chosen as it allowed me

through face-to-face interactions of group interviews to view and explore these journeys through individual's thoughts and words (Bryman, 2008).

In order to gain an initial understanding of the potential key factors impacting on trainee PCK and to establish relationships to the key literature, I decided to utilise written questionnaires. This gathering of quantitative evidence was an efficient scoping exercise and enabled me to establish lines of enquiry that were then explored in greater depth during the interviews in the second stage of my study. Through interviews I was able to extend my understanding of the development of trainees' PCK through the gathering of qualitative data, focused initially around the key themes identified in my literature review and the questionnaire scoping exercise. Additionally I was able to seize upon opportunities to explore other themes as they emerged within the interviews.

Initially I had aimed to conduct an evaluative comparison of the effectiveness of each route. However as Training Manager of both routes I felt that it was important that I respect the value of both routes into QTS, and I did not wish to demean the potential of either to effectively train primary teachers. I wished to examine the generic aspects of teacher training, common to both routes that lead to the award of QTS. It was the potential impact of key components of the training year and not the particular route chosen that was important in this study. At the same time, the structural differences of each route (See Appendix A for an overview of each route) enabled me to examine whether the balance of time and priority given to each training experience on each route, had an overall effect on the trainees' development of mathematical PCK and their confidence level within the classroom.

3.2 Identification of lines of enquiry

A collective case study approach was followed in which the impact of aspects of the initial teacher training year on development of mathematical PCK were examined through the

collation of data utilising a mixed method approach. The analysis of this data enabled the creation of a theory about how trainee teachers develop mathematical PCK.

The initial lines of enquiry were based on an in-depth scrutiny of literature related to the ways in which trainee teachers learn to teach (See Chapter 2). The key aspects of practical experience of planning and teaching; theoretical knowledge gained through centre-based training; observation feedback and discussions; mentoring support and observations of good practice, being identified as having a potentially beneficial impact on PCK development. At the same time as a result of my literature review I wished to examine aspects that could be perceived to have a detrimental effect including the context and expectations of the school and trainees' perceptions of mathematics as a result of their own education.

In consideration of this, the key question for this study was:

How do primary initial teacher training trainees develop their mathematical pedagogical content knowledge (PCK) during the training year?

From this key question, the following lines of enquiry were defined:

- What is the role of the school, and school-based training, in developing trainees' mathematical PCK?
- What is the role of centre-based training in developing trainees' mathematical PCK?
- To what extent is centre and school-based training interlinked in supporting the development of mathematical PCK?
- Which elements of the training year do trainees perceive to have the greatest impact on the development of their confidence in mathematical PCK?

3.3 Case study approach

In order to explore these identified lines of enquiry a case study approach was followed; this allowed me to adopt an interpretivist stance in order to investigate the trainees' explanations in relation to the particular elements of the course which they perceived to have had a high level of impact on their confidence levels and development of mathematical PCK.

The case focused on the experiences of primary trainee teachers within one particular ITT provider, collating the experiences of a number of trainees and the viewpoints of some of the key personnel working alongside the trainees within the school and centre-based setting. This approach allowed for greater generalisation, as findings were not confined to just one participant and through the use of group interviews there was the opportunity for the sharing of experiences; this allowed patterns to be drawn out (Stake, 1995). Each participant played an instrumental role in constructing an overall view of how trainee teachers within the ITT provider develop mathematical PCK.

The case was bounded by the particular routes into qualified teacher status that it focused on. The provider in this study offered solely a SCITT approach to qualified teacher status (See Appendix C). Within this the participants had chosen either a PgCE or EBITT course. Data gathered from the interviews in relation to why a particular route had been chosen, highlighted that aside from financial reasons - the EBITT route provided a salary as a qualified teacher for the training year, whilst the PgCE route is unsalaried and tuition fees must be paid – trainees predominantly chose a route based on their perception of the best way in which they learn and also the amount of previous experience that they had gained in schools. (See Appendix D – Overview of trainees' rationale for choice of route). With this in mind it was taken into consideration that EBITT trainees may place more value on the school-based elements of the course, with PgCE trainees being more likely to look for a balance between the centre-based and perceived practical elements of a course.

Particular types of case study have been identified (Stake, 1995). The intrinsic case study is where the researcher is purely concerned with learning about the case itself, and does not possess a particular interest in its generality. The converse is the instrumental case study in which the answers to a general puzzlement or question are sought through the study of one particular case. For this particular study there were aspects of each. Overall my primary aim was to explore a theory in relation to the impact of both theorised learning and practical experiential learning, in developing trainee teachers' understanding of the pedagogy of mathematics, and how levels of confidence develop in relation to the teaching of mathematics within the primary classroom. At the same time, there were also some elements of internal generality as the findings related to the development of PCK in mathematics could be applied to other areas of the primary curriculum.

The use of the same approaches across multiple participants allowed findings to be generalizable and applied to other cases (Bassey, 1998). Although not within the scope of this study, this aspect might have been further strengthened through the study of additional cases from other ITT providers. It could therefore be argued that this study is 'instrumental' in that it aims to bring about an answer to the questions of "What aspects of ITT have the biggest impact on trainee development?", "How does a trainee teacher develop their pedagogical subject content knowledge?" and "How do the theoretical and practical elements of the ITT year complement each other to develop trainees' PCK?"

The extent to which generalisations can be made from a case study was examined (Stake, 1995; Yin, 2003). Stake (1995) suggests that it is the process of looking for patterns and meanings in responses to activities or problems, and examining the reoccurrences and consistencies, which allows generalisations to be made. Lincoln and Guba (1985), refer instead to transferability in which the recipients of the findings of research consider for themselves the extent to which the information can be transferred and applicable to their

particular case. The range of methods deployed within this study (interviews, questionnaires, scrutiny of documentation and observation of taught sessions), and the sample size (a total of 26 trainees – 15 EBITTs and 11 PgCEs) allowed some scope for the identification of recurring patterns.

Some factors were anticipated as they had already been highlighted through the literature review (See Chapter 2) and these formed the basis of the initial quantitative questionnaire element of the study. These aspects included a view that: practical ideas from centre-based training, hands-on experience of teaching, observations of good practice and feedback from mentors will have an impact on trainee development. It was expected however that some issues would emerge unexpectedly and as a result of the investigation, particularly as a result of discussions at interviews (Silverman, 1995; Stake, 1995). It was my openness to these emerging issues that added internal validity to the study.

The case study approach to investigations can be viewed as a weak method, (Yin, 2003) as it can lack in objectivity and rigour. Combined with potential concerns over the analysis of qualitative data, and issues associated with insider research, it was important that the methodology of this study at all stages was examined with a high degree of reflexivity. These aspects will now be considered.

3.4 Data collection approaches

A range of data collection approaches has been utilised to enable the identification and measurement of key aspects of the lines of enquiry. Table 1(overleaf) provides an overview of the lines of enquiry that were followed within each data collection approach.

	Questionnaire	Group interviews (Trainees and Mentors)	Tutor Interview	Scrutiny of trainee lesson observation reports	Observations of mathematics centre-based training session
Trainees' perceived confidence level at key points of the training year	✓	✓	✓		
What the trainees have learnt/ developed	✓	✓	✓	✓	✓
How they have learnt/ developed	✓	✓	✓	✓	✓
Barriers/ challenges they have encountered and how overcome	✓	✓			

Table 1: Overview of data collection approaches

Appendix E provides a timeline for the different stages of data collection.

3.4.1 Questionnaires

Within the quantitative element of this study, a questionnaire (See Appendix E) utilising attitude scaling was used to gain an overview of the trainees' perspective on the level of impact particular aspects of the course had on the development of PCK in mathematics. This quantitative methodology was chosen as it enabled me to quickly gain an overview of impact, and this data was then utilised to generate further lines of enquiry that were followed up in the interviews. I was aware however that care must be taken when using quantitative data (Cohen et al, 2006; Gorard, 2004), as the results should not be seen as real measurement, as the researcher cannot be assured of the relative value each respondent has given to each of the criteria - that a tick in a certain part of the scale for one person may

not mean the same thing to another person and that all trainees may not have a common understanding of exactly what a high level of impact means. In consideration of this, it was important to back up my quantitative findings with qualitative explanations within both the latter part of the questionnaire and the group interviews.

In order to gain a greater understanding of the particular aspects of the training year that had an impact on trainee confidence in mathematical PCK, open questions were included as part of the questionnaire as I was aware that they have the potential to provide a more in-depth and authentic insight into experiences (Silverman, 1995). However at the same time these type of responses can be less straight forward to analyse, and respondents can find answering these questions time consuming and challenging (Silverman, 1995). This was something I noted from the responses on returned questionnaires, with these areas often being sparsely answered. It was also necessary to take into consideration the stage of the training year in which the questionnaires were completed. At the start of the training year the trainees being new to ITT may not be as adept at communicating their perspectives on factors impacting on their learning, compared to the end of the year, when they are much further on in the developmental process. The wording of the questions was tested in the pilot study, and the written responses gathered indicated that although limited in some cases, provided enough information to establish lines of enquiry for the interview stage of the study. I acknowledged that it was important that I didn't rely solely on data gathered through questionnaires but additionally gained a greater depth of understanding through the interview process.

3.4.2 Semi-structured interviews

The potential for the exploration of all possible lines of enquiry was the reasoning behind the inclusion of semi-structured interviews within my methodology. Yin (2003), highlights how a move away from a purely formulaic and structured style of interview can lead to a conversational approach in which the participants feel free to speak about their experiences

with ease. This approach fitted best with my research questions as it allowed the opportunity to explore the full range of factors impacting upon trainees' development of mathematical PCK, and not confined by a pre-determined list of influences. The semi-structured approach provided the trainees with a sense of freedom in which they were able to explore or raise the issues that they felt were important, rather than having to adhere to a rigid schedule set by the researcher. This approach also enabled me to challenge any pre-conceptions about the trainees' experiences and so allow greater internal validity.

Group interviews were chosen as they allowed more readily the exploration of contradictions and differences within the case study (Bryman, 2008). A potentially rich source of data could be provided when discussions develop as trainees' viewpoints spark off ideas and comments from each other (Cohen et al, 2006; Kitzinger & Barbour, 1999; Macnaghten & Myers, 2004). At the same time careful management of this type of interview was vital to ensure that conversations did not lose focus; one person did not dominate the conversation leading to a biased viewpoint, and that participants who remained silent were allowed the opportunity to contribute their thoughts at some time during the interview. I enabled this through the careful management of time (not allowing one trainee to speak for longer than 5 minutes), and also through the re-direction of a specific question to a trainee who had not spoken, so ensuring that everyone had an equal opportunity to contribute. This was challenging at times as trainees were enthusiastic about sharing their experiences in detail, and they found it particularly cathartic when discussing challenges they had overcome. However it was important that I gained a range of viewpoints, and in instances where trainees had experienced challenging situations it was beneficial to gain an overview of whether this was a one-off isolated situation, or whether it was common to more than one trainee.

Additionally the interview stage of the research process can be difficult to arrange and the most time-consuming element of a research project (Cohen et al, 2006; Oppenheim, 2005).

With this in mind it was decided that group interviews would be a good way forward for practical reasons as a range of points of view could be gained within an allocated time-span.

The pilot study provided the opportunity to refine my role as interviewer. Within the first pilot interview, the participants were quite formal in their responses, with each person feeling that they had to take it in turns to answer and this did not allow the discussions to develop in the natural and free-flowing way that I hoped with interjections (Bryman, 2008; Cohen et al, 2006). I had prepared a discussion card for use during the interview, which linked to my literature review and outlined the main ways by which trainee teachers perceive that they learn to teach (See Appendix G), and I noticed that when I introduced this in the second half of the interview, the conversation opened up, as the points acted as a common focus for discussions. As a consequence in subsequent interviews I made two changes. Firstly, when providing an oral overview of procedures and expectations at the start of the interview, I stated that the trainees did not have to wait to speak in order, but that they could contribute ideas, as and when they felt relevant, and that the format should be more of a discussion rather than an interview. I also emphasised the need for them not to talk over each other so that everyone could be heard. Secondly, I introduced the discussion card at a much earlier stage. This was largely due to the success at the previous interview, but also as a result of reflection I became aware that my planned questions were really only a replication of the key elements outlined on the discussion card, so such repetition was not necessary. At times the discussion card acted as a recap for aspects already covered naturally in discussions, and an opportunity for trainees to consider, and possibly discount aspects they had not considered yet. These changes meant that the format of the interview took more of the form of a focus discussion; where conversations did not take place as backwards and forwards between the interviewer and participants, but instead became discussions within the group centred round the stimulus which the interviewer had supplied. (Cohen et al, 2006)

Morgan (2006) suggests that group size is normally six to eight for group interviews, but this was not the case for this study as I did not gain sufficient volunteers. Despite the overall small number of participants I still wished to ensure a degree of validity by splitting each cohort into at least two groups of between two and four trainees. This ensured that through comparing data and findings across sub-groups, I was able to come to more valid findings.

Overall the conversations were productive, and generated lively debate, with trainees enthusiastic about sharing their thoughts and experiences, and other trainees responding with affirmation and provision of their own examples, which reinforced key points. At times it was important to move the conversation on, as some trainees became focused on providing minute details about aspects of a lesson they had taught. Instead what was key to the study was the drawing out of what they had learnt from an experience, what their next steps were in developing their practice, and what influenced their decisions. Discussions were moved on through careful questioning, or the initiation of a response from another trainee. Bryman (2008) suggests that group interviews also allow the exploration of contradictions and differences within the group. On the whole, the trainees tended to confirm comments made by their peers, rather than contradict. This sharing and comparing process (Morgan, 2012) was expected as the trainees were experiencing the commonality of undertaking a teacher training year. Although this could be perceived as positive, as it provided strength and affirmation to my argument, it was important to be mindful that this lack of contradictions and differences within the group could have been due to the trainees' reluctance to speak up in disagreement. For this reason correlation was explored across the interview groups, and across other forms of data collection.

I was also aware of the importance of ensuring that the data I gathered linked specifically to the trainees' development of mathematical rather than general or other subject specific PCK. I achieved this through stating this at the beginning of the interview, and then ensuring that my questions made specific reference to mathematics. There were times when I felt that the

trainees may have begun to speak more generally, and on these occasions, I re-directed them back onto mathematics.

Gubrium and Holstein (2012: 33), stress the importance of neutrality within the interview process, and the need to 'control one's opinions as an interviewer so as not to influence what the passive interview subject can communicate.' A detachment from the emotion of any comments that were made by the trainees was therefore important, and any remarks were limited to affirmations of the comments or questions with the aim of extracting deeper explanations. The role I undertook was of an active interviewer (Holstein and Gubrium, 1995). An initial question focusing on why the trainees had chosen their particular training route was introduced, and this provided the participants with a fairly straightforward introduction to the discussion. Subsequent questions were then developed with the aim to unearth the particular features of the training year that the trainees perceived to have had an impact on their development of mathematical PCK.

In the role of active interviewer I also wished to enable the participants to elaborate on the answers they had provided, without determining their responses. My key aim was to determine what aspects of the training year the trainees draw upon within the processes of planning, teaching, evaluating and reflecting. Therefore my questions were carefully chosen to elicit this information, without making predetermined suggestions.

Another issue that was an important consideration was in relation to the timings and the stage of the training year the interviews were conducted. Hammersley and Atkinson (1995) state that it is important for the researcher to consider, when interpreting the data, the ways in which the timing of the collation may have been affected by events either preceding or following it. With this in mind I chose to conduct the interviews in June of Year 2 as this ensured that both cohorts had completed substantial teaching (for a period of at least six

weeks in succession), in two primary schools (See Appendix A for overview of school-based training expectations).

3.4.3 Observation of centre-based training

As discussed in Section 2.1, centre-based training was considered to be a key theoretical aspect of the training year. With this in mind, I felt that it was important that I observed a mathematics lecture in order to ascertain the exact nature of the sessions. As I did not wish to influence the usual pattern of trainee, tutor and task interactions within the session I chose to undertake non-participant observation (Bryman, 2008). I wished to be systematic (Bryman, 2008) in my note-taking during the observation, and as I was focusing on the occurrences of particular aspects of teachers' mathematical knowledge I chose to utilise the categories of content knowledge (subject knowledge per se for mathematics), curriculum knowledge (materials and tools for the teaching of mathematics) and pedagogical content knowledge (Shulman, 1986) to categorise each minute of the three-hour session observed. This allowed me to analyse the type of mathematical knowledge developed during the session and the balance between different elements including the focus on mathematical PCK. Appendix K provides a sample of the data gathered and my analysis.

3.5 Participation

Within this study a non-probability sampling method was used with trainees self-selecting. I chose an invitation to participate approach as I did not wish to put undue pressure on trainees to take part as I was aware that the ITT training year was already time intensive. All the 2012-13 cohort of 73 primary trainee teachers were invited to take part in year two so I anticipated that I would gain sufficient response across both routes in order to gain a reasonable sample size, so allowing patterns to be generated. As I also wished to conduct group interviews, it was important that the number of participants in this aspect of the study were also sufficient, with the aim of at least six trainees from each route, so allowing two interviews of at least three trainees to take place for each.

The response to my request for participants generated a reasonable response (See Table 2) and enabled me to proceed with all planned elements of data collection as planned, although I recognised that considering the overall cohort size the sample was fairly small.

Aspect of the study	Number of participants	
	PgCE	EBITT
Questionnaires	11	15
Group Interviews	6	7

Table 2: Overview of initial number of participants in aspects of the study

It was important that I gained a reasonable sample of trainees who participated in the questionnaire aspect at both the beginning (November) and end of the training year (July), as this would allow me to track confidence levels, and link this to determining factors. To enable me to track this, I number coded each questionnaire participant. This meant that anonymity of each respondent was maintained whilst I was extracting data from each questionnaire, but allowed me to follow-up any non-responses through a reminder email. This method allowed me to gain 100% (n = 26) return rate in November, and 67% (n = 18) return rate in July. Cohen et al (2006), suggest that a response rate of at least 40% should be expected. Recognising that the overall number of participants was relatively low, the response rate in this study could be considered to be at a high level in the autumn term and at a good level at the end of the course. I considered the data gathered in the summer term to be of most importance as this was when trainees were most aware of the impact particular aspects of the course have had on their confidence level and development of mathematical PCK, as they had just completed their final teaching practice and were about to enter their newly qualified teacher (NQT) year.

It was necessary for me to consider the potential for bias within my sample. For this study I chose to focus on the development of mathematical PCK in primary trainee teachers in general, and although these trainees could be classified in a number of ways: gender, age and primary age phase working within, this was not within the scope of this study. A simple analysis of participation (See Appendix J) showed that participants were representative of the cohort as a whole, with trainees from across all age groups, genders, and primary age phases. This representation also indicated that there was no potential bias attached to non-participation of certain groups (Oppenheim, 2005).

As this was not a comparative study of the two routes into qualified teacher status (EBITT and PgCE), it was not important that I had an equal balance of participants from both routes. However by obtaining a viable number of participants from both, I was able to note any patterns that occurred in relation to the differing structures of the training year (See Appendix A – Overview of routes).

Another important aspect of the choice of methodology was the provision of opportunities for triangulation. This was a key element in terms of validity, and vital as this was research from the inside (Cohen et al, 2006; Ravitch & Wirth, 2007; Stake, 1995). Two different approaches to triangulation - methodological and data source were utilised within this study (Stake, 1995). This was achieved through the involvement of a range of parties within the study – trainees, mentors and tutors. This allowed different perspectives to be gained, and ideas challenged or strengthened. A total of 36 mentors (15 PgCE and 21 EBITT) provided their perspective on how trainees develop mathematical PCK and their role in the process via a written questionnaire (See Appendix Q). Additionally two mentors and the mathematics tutor were interviewed about their role. The mentors were interviewed together face-to-face. This took a semi-structured form, in which a series of pre-determined questions focusing on their role in supporting trainees' mathematical PCK were asked, and then further lines of enquiry were explored as they arose during discussions.

3.6 Ethical considerations

It was vital that all participants in the study were safeguarded. This is highlighted by Sikes & Potts (2008: 8), who state that, “alertness to the risks of othering, and of in anyway doing harm to anyone, including the researcher himself should be pervasive and paramount.” As I was completing research within my own work environment alongside my role as Training Manager, it was important that my credibility and respect in both roles was preserved. Literature focusing on the issue of ethics (Cohen et al, 2006; Miller & Glassner, 1997; Smyth & Holian, 2008; Van den Berg, 2001) highlights the key areas of informed consent, anonymity and confidentiality. Open University ethical approval was gained before I commenced the study and I ensured that all elements met British Educational Research Association ethical guidelines (2011).

3.6.1 Informed consent

In order to enable informed consent an overview of the purpose, aims and methodology of the study were outlined to potential participants in the form of a consent letter (See Appendix I) and an oral presentation. This took place at the end of a centre-based training session at the beginning of October. This timing was chosen as all the trainees had time to settle onto the course, having spent at least two weeks within the school environment and also completed 10 days of centre-based training so were aware of the key aspects of both elements of the course. The consent letter reiterated the key focus and elements of the study, and also ethical considerations. This allowed the trainees to take the information away and the expectation was not for an immediate response, so avoiding a feeling of pressure to conform or participate. I was also open to any follow-up questions regarding my study, and one trainee requested additional information about the format of the group interview element prior to agreeing to participate. It could be questioned (Eisner, 1991) whether the researcher can actually be totally assured that the participants have the same understanding of the project as themselves, and in that way whether their consent is ever

truly informed. However I believe that by presenting the information in two ways and providing an opportunity for questions I ensured that trainees could make an informed consent. Alongside this focus on consent it was important that the participants had a genuine opportunity to opt in or out, both at the start of the study and at a later date (Smyth & Holian, 2008). At the start if trainees chose to not opt into particular elements or none at all then this was not followed up on a personal basis, although a general reminder that trainees could still take part was issued to everyone two weeks later.

The demand on participants in terms of their time was an important consideration (Hammersley & Atkinson, 1995; Ravitch & Wirth, 2007). The training year is already very demanding for trainees and I did not want to unduly increase these demands, although I was aware that I could not diminish this impact completely. I believe that the time expectations could have been a factor in whether particular trainees chose to participate or not, and if they did which elements they engaged with. It was noted that the most selected element of participation was the written questionnaire (26 for the questionnaire compared to 13 for the interviews) and it could be perceived that this would be the least time consuming of all aspects, and one which the participant would have a greater degree of flexibility in choosing when they complete it. Also participants may have wished to avoid the personal interrogation features of face-to-face interviews.

Another important aspect of consent was the need to ensure that trainees had some awareness of the purpose of the study, and to reassure participants that the project was not about personal gains for the researcher (Ravitch & Wirth, 2007), but focused on investigating the ways in which trainees develop their mathematical PCK and the best model for this. This was made clear in my explanation of the study, but at the same time I needed to be open and honest about the fact that the impact was likely to be felt by future cohorts rather than the present one. Alongside this was the important reassurance that their participation or

non-participation would not affect their progress or grades on the course (Ebest, 2001). Although I am the Training Manager I had no influence on the grades the trainees received as these were decided by the school mentor and/or external visiting tutors. This was apart from three EBITT trainees for whom I was fulfilling a visiting tutor role. I needed to question whether I should exclude these trainees from the study. Only one of the trainees concerned chose to take part, and this was only in the questionnaire element, so I decided that I would be able to separate my roles and act with objectivity, including not allowing myself to refer to or utilise any information gained from either of my roles (visiting tutor or researcher) in the other context.

3.6.2 Anonymity and confidentiality

A level of anonymity was guaranteed within the questionnaire aspect of the study through the use of the four-digit number coding system (See Section 3.5). This ensured that when collating and analysing data the responses were solely linked to a number and not a name. The benefit of this approach was that participants may answer the questions with greater candour and honesty if they felt they were able to remain anonymous. This was a particularly important consideration for this study as I was both a perceived insider and in a position of power (See Sections 3.6.3 and 3.6.4). Anonymity was also guaranteed in any interim reports and the final thesis, with the names of any participants anonymised. When transcribing interview data participants were referred to only as a number.

In the role of qualitative researcher confidentiality was key (Portelli, 2008; Smyth & Holian, 2008). Aspects relating to confidentiality were reinforced at the beginning of the interview. The initial consent agreement (Appendix I) outlined the ethical aspects of the study, but it was also important to reinforce orally that the information they provided in the interview would not be shared with other people within the teacher training organisation, including tutors or mentors, and that it would not affect any decision pertaining to their award of qualified teacher status.

I was aware that the trainees might provide me with information that could be considered to be damaging to themselves: they may disclose information about their performance on the course or professional attitude, or alternatively they may not do credit to colleagues, such as the mentors or tutors, or to particular schools. I felt that this was one of the most challenging aspects of my research, as in my role of Training Manager I felt a desire to act upon it, but at the same time as a researcher I was bound by an ethical code of practice as exemplified in the BERA Ethical Guidelines (2011). Even though I was pleased when I heard about particularly good practice, and disappointed when trainees shared negative experiences, I ensured that individual situations were not acted upon as a direct result of the data collection process.

Overall the trainees did not reveal any information that could be considered damaging to themselves, although I am aware that their responses may have been chosen at times to avoid such disclosures. Also no disparaging information was given about the core tutor for mathematics or the centre-based training aspects of the course – this may have been due to the high level of effectiveness, as reflected in the outstanding grade for the mathematics course (Ofsted, 2013). However three trainees provided several negative comments in interview about the support they had received in their schools. As Training Manager I did find this challenging as I aspired to a high level of support for all of the trainees. However the information provided to me was something I was already aware of, and I was confident that the situation had been managed effectively already within the provider, so this negated my desire to act.

3.6.3 Insider research

My role as Training Manager meant that I could be considered to be undertaking insider research (Adriansen & Madsen, 2009; Dwyer & Buckle, 2009; Hellawell, 2006; Miller & Glassner, 1997; Ravitch & Wirth, 2007) – fulfilling a dual role as practitioner and researcher.

With over twenty years of experience working with the organisation (See Section 1.5) it could be said that I offered a unique perspective (Smyth & Holian, 2008) on the culture, history and function of the provider. At the same time if applying the definition of insider as someone who works on par with the participants in the research (Adriansen & Madsen, 2009) it could be said that I was not an insider in my context, as I was not a trainee teacher (Dwyer & Buckle, 2009). As such I was not fully immersed in the trainees' sub-culture, although I was both an observer and facilitator of their experiences. At the same time, it could be argued that when gaining the perspective of the mentors and tutors working with the trainees, I was more of an insider, as I tutored on the course (albeit not within mathematics), and I was involved in the process of mentoring and observing trainees whilst on school practices.

Research (Adriansen & Madsen, 2009; Mercer, 2007; Ravitch & Wirth, 2007; Smyth & Holian, 2008) highlights the advantages of being an insider within a study. The positives are centred round the prior knowledge of the organisation, and the relationships already established. I was familiar with the terminology used within the course, its structure and the key components, so I did not need to carry out additional research in this area or seek clarification on technical points either before or during the research. Practical elements were also an advantage, including the highest level of freedom of access being assigned to me as an insider, and data collection being less time-consuming as participants were more readily accessible.

At the same time criticism of this form of research focuses on the degree of objectivity that an insider can bring to their work, and in turn the reliability and validity of the findings need to be considered (Sikes & Potts, 2008). It has been questioned whether "pure objectivity" (Smyth & Holian, 2008) can be achieved in any study as whether an insider or outsider, the researcher will always bring pre-conceived ideas, through either intimate knowledge of the context of the study itself, prior personal experiences, or ideas formulated through the scrutiny of background literature from other researchers prior to the study. Mercer (2007)

suggests that insider researchers wield a double-edged sword in that there are gains to be made in terms of the previous knowledge of the workings of the organisation that they hold, but these need to be considered alongside any potential bias or shortsightedness that may occur if the researcher makes assumptions based on their previous experiences. With this being the case it was important that I demonstrated a constant awareness of the issues and took steps to limit the impact.

I considered the need to be open to the thoughts and perspectives of participants and to avoid making assumptions, through a belief that I already understood the context (Mercer, 2007; Ravitch & Wirth, 2007). Within interviews it was important that I allowed the participants time to fully explain their thoughts and ideas. At the same time I ensured that through good listening skills I did not bring to the fore in any comments, preconceived ideologies based on my own experiences or aspects of theory I had engaged with (Yin, 2003). My role was to allow the trainees to communicate their own perceptions and stories and then search for patterns and links to theoretical aspects, not allowing assumptions to be made at too early a stage (Delyser (2001). In order to obtain a depth of understanding it was important that I used questioning to follow-up lines of enquiry, but avoided the use of leading questions as these may have influenced or biased the response.

It was advantageous at times to take the stance of someone who knew very little about the aspect being explored, so that areas were examined in more depth. This can be challenging as participants themselves may come to the interview stage with a view of the prior knowledge that the researcher possesses and so may not elaborate on points in the same way that they would do with an outsider (Adrianson & Madsen, 2009). To achieve this I asked the trainees to "Talk me through the process of an observation" so that I could gain an understanding of the stages from the trainees' perspective and from reality, and not from my own perceptions of how it should be. I also ensured that I frequently asked probing questions, in order to establish the trainees' viewpoints on how and why things are so.

3.6.4 Power relationships

A consideration of the influence of power relationships (Hellawell, 2006; Mercer, 2007; Portelli, 2008; Smyth & Holian, 2008) was an important aspect, as it provided an added dimension to the considerations of insider research. There is an element of power in all aspects of every study (Portelli, 2008), as even the participants are able to exercise power over their responses and what they choose to say, or not say. Although there was no way to eradicate this power differential, its effects needed to be acknowledged and steps taken to ensure that it did not affect the validity of findings.

Ethical considerations, relating to consent, confidentiality and anonymity (See Section 3.6.2) were key to limiting the impact of power relationships. Central to this was the development of trust and rapport between the participants, and myself, in my role as researcher, rather than Training Manager. Without this establishment the responses may have been constrained, leading to a biased view of the situation. By including elements of the study where the participants could maintain anonymity it was hoped that a greater degree of disclosure was obtained. A comparison of the findings from the anonymous and non-anonymous aspects of the study did not reveal any key differences. I also felt that a high degree of honesty was achieved from the trainees - demonstrated by the level to which they revealed both successes and challenges within the training year, including instances where mentoring processes or particular aspects of the context of the school had been detrimental to their development. I believe that the group nature of the interviews supported this level of honesty, as trainees may have felt more at ease in this type of situation, compared to one where they are on their own and face-to-face. The group situation allowed them to sit back and listen at times, whereas individual interviews by their nature have a more intensive focus on the interviewee for the duration – which some people may find stressful and constraining.

During interviews it was important to ensure that my responses did not lead to the participants feeling that they were being judged. I avoided making judgmental comments about what I heard; purely acknowledging what the trainee was describing, and including only carefully considered questions or comments.

3.7 Data analysis

This section will outline the methods I utilised to analyse the data gathered (See Appendix E - overview of key stages of my research). Some of my initial findings will be outlined, including how these developed my lines of enquiry in the latter stages of the research. These findings will be analysed and discussed in greater depth in Chapters 4, 5 and 6.

3.7.1 Use of quantitative data to identify themes

Questionnaires completed in November of the training year were utilised as a scoping exercise with trainees on both routes being asked to rate the perceived impact of particular aspects of the training year on their development of mathematical PCK (See Appendix F). Attitude scaling was used with a five-point scale (1 = no impact and 5 = high impact). As I wished to look at the aspects which had the greatest perceived impact on trainee development I decided to focus on cells 4 and 5 (the higher levels of impact) when analysing the overall results. I considered cell 3 to correspond to an average level of impact. I was aware that with a five-point scale there is sometimes a tendency for participants to avoid the two extreme options on such a scale, with the result that the perceived safer option of the mid-ground, in this case point three, being chosen. With this in mind I considered the spread of results seen on individual questionnaires. There appeared to be a good spread of points chosen, including all of the possible options, suggesting that the participants had considered with some thought their choices rather than opting for the middle-ground. I therefore judged that this was not an issue.

The findings are shown in Table 3.

Aspect of the training year	Number of trainees rating the impact as higher than average (Sample size = 26)
Observation of good practice	20
Practical experience of planning, teaching and assessing	17
Feedback from observations	16
Own reflections on your teaching of maths	15
Discussions with practitioners	14
Centre-based training	12
Private Research	8
Own experience of learning maths at school	7
Own experience of teaching maths prior to the course	6
Discussions with other trainees	6

Table 3: Trainees' perceptions of the potential level of impact of aspects of the training year on their development of mathematical PCK

This quantitative data analysis allowed me to identify and rank the aspects of the training year, in the first term of the training year, which trainees perceived to have the biggest potential impact on their development of mathematical PCK. I was then able to identify lines of enquiry that were followed up in the interview stage of the process. For example, 20 of the 26 trainees had indicated that observation of good practice had a high level of impact on their development, as result of this I wished to explore in more depth, through my direct questioning, how trainees were able to identify particular aspects of good practice, why they perceived the practice to be effective, and as a consequence how they replicated this within their own teaching.

As a result of this analysis of the quantitative information the following lines of enquiry were established for the interview stage of the study:

- How do trainees make sense of what they observe within the classroom? How do they then transfer this into their own practice?
- What do they draw upon to improve their practice in future lessons?
- When undertaking planning for a mathematics lesson, what sources of information do trainees draw upon in order for them to plan an effective lesson?
- What targets have trainees been given following an observation of their mathematics teaching? Are these related to the development of their mathematics teaching or more generically to teaching?

This quantitative data was also linked back to key theories examined in the literature review. I noted that trainees' own experience of learning mathematics at school did not appear to have a high level of impact on their confidence level, and this appeared to be converse to research in this area (See Section 2.4.1). Although I did not discount this aspect at this stage, it did not appear to be a strong determining factor in relation to this study.

The qualitative aspects of the latter part of the questionnaire were also collated and analysed using a funnelling system (See Section 3.7.3), where similar ideas across scripts were grouped together and recorded in the form of a matrix grid, allowing me to cluster together commonality across trainees (See Appendix K). For each key question I began to identify themes. These were not pre-determined and evolved as I examined each trainee response. For example in regard to the question focusing on how centre-based training had developed the trainee's confidence in the teaching of mathematics, comments were clustered around themes including: subject knowledge, strategies, resources and progression. I used colour coding (Yellow for PgCE and blue for EBITT) to enable me to note any specific patterns amongst trainees on and across both routes. This matrix system was effective as it allowed to me quickly determine aspects of strong impact. This

information was followed up within the interview process and also used to provide additional evidence in relation to my overall findings.

3.7.2 Transcription of interview data

The verbal responses of each interview were transcribed by myself. Transcribing each interview in its entirety meant that I was able to ensure that all aspects of the discussions were formally recorded. Key points that may be relevant at a later stage were not missed out, so enabling me, with ease, to revisit any aspect if necessary at a later date. The anonymity of each participant was maintained on the transcriptions with each participant being referred to by a number.

3.7.3 Grounded Theory Approach

Following the transcription of each interview the process of analysis was undertaken through a grounded theory coding approach (Werz et al, 2007). Data was funnelled and sorted through the use of categories and codes, which emerged through my interactions with the data. Patterns were identified, and findings were compared and aligned with previous theory (Hammersley & Atkinson, 1995). The aim was to identify a stable set of categories that would allow analysis to take place around the central themes, which had been identified. As each group had followed different pathways during their interview, led by ideas and discussions that arose, I decided not to conduct thematic analysis based on interview questions. Instead my analysis followed the initial key themes that had underpinned my qualitative data collection as a whole:

- What have the trainees learnt/developed in relation to mathematical PCK?
- How have the trainees learnt/developed this?
- What barriers/challenges have the trainees encountered and how have these been overcome?

Highlighter pens and annotation on the interview scripts was used to highlight key information related to each specific question and then transferred to an A1 sheet of paper so that information could be collated under the particular theme headings (See Appendix K). These themes tended to group around particular features of the training year, linking mainly to aspects whose level of impact had been ranked highly within the quantitative element of the questionnaire, including reflection, observation of good practice and discussions with class teachers/mentors. I was conscious not to limit the scope of each statement and to make links across themes - if a statement linked to more than one theme then it was recorded in all areas. Morse (2012) suggests that during thematic analysis, themes may be foregrounded, backgrounded or only inferred. It was therefore important that I viewed trainee statements in this way so that I could categorise and elicit meaning. For example, explicit comments were made about learning from teaching, or learning as a result of the process of reflection. These were categorised as 'teaching' and 'reflection' in a straightforward way. However a number of trainees also referred to 'learning by mistakes'. This aspect could be seen to generate a new sub-category, but it could be inferred to relate also to both 'teaching' and 'reflective practice'.

My decision to engage with the data myself and sort and collate the information by hand rather than electronically meant that I was able to fully immerse myself in the information I had gathered. Alongside the time spent during the interview and the transcription of the data, this was the third time that I was able to engage with the information in its entirety. This enabled me to have a clear view of each interview allowing me to formulate connections both within and across interviews. However it was important to recognise that this process could lead me to miss key ideas due to the scale of the information gathered and the time taken to funnel the data. With this in mind it was important that I revisited the funnelled data to search for any inconsistencies, and that I paid particular attention to any data, however small, that I hadn't assigned to a particular question or theme. This revisiting also enabled me to reflect upon whether I had interpreted the data accurately or whether my own pre-

conceptions or expectations had led me to interpret it in a set way. It was important that my findings reflected the trainees' viewpoints and not my own.

Following the funnelling process of each interview I looked for overall consensus across all interviews, and then across cohorts (PgCE and EBITT) to identify ideas which shared a commonality with a number of trainees regardless of route, and ideas which displayed uniqueness to one cohort. This was achieved by separating out the themes from each individual interview and then collating all of the interviews as a whole under separate themes.

Four themes, related to how trainees develop their confidence in mathematical PCK, which have commonality across both cohorts emerged:

- The role of reflective practice
- Gaining an understanding of progression in pupils' learning within mathematics
- The importance of support
- The role of centre-based training in mathematics

For the EBITT trainees a fifth theme, 'The importance of the second school placement' was also found.

Each theme will be examined in depth in Chapters 4 and 5.

3.7.4 Developing lines of enquiry

The scrutiny and analysis of questionnaire and interview data indicated that trainees found observation feedback valuable. This led me to consider to what extent this feedback focused on the development of mathematical PCK. As this had not been identified as a line of enquiry at the outset of my study, and it had emerged through my findings, time

constraints meant that I was unable to record or sit in on actual mentor feedback meetings. I was also conscious that if I was present at meetings then the mentor might respond differently to their norm; being aware of the focus of my study. I therefore decided to examine a range of written observation reports. As these had been written under normal circumstances, without my study as a focus, it can be assumed that they reflect the normal pattern of comments made by the observer.

A total of 40 mathematical observation reports were collated, across both cohorts, from a range of trainees and observers. A coding system (Lock et al, 2009), which categorised comments into: topic specific pedagogy, class management and generic issues was utilised. The observation reports were colour coded using the different categories, and the total number of statements for each category recorded. Any specific comments related to mathematics pedagogy were also noted. I also wished to analyse the extent to which the targets set related to mathematics so these were also recorded. (See Appendix L and M for colour coded sheet example and analysis overview).

Research related to the analysis of mentors' written lesson observation reports (Lock et al, 2009; Soares & Lock, 2007; Spear et al, 1997) and discussions (Borko & Mayfield, 1995) highlights how feedback often focuses on classroom and behaviour management strategies and generic aspects of teaching, rather than highlighting aspects of topic-specific pedagogy and/or subject knowledge. Therefore through my analysis I wished to ascertain to what extent lesson observation feedback did focus on and develop specific mathematical PCK.

3.8 Summary

In summary this chapter examined the methodological processes undertaken and provided a transparent rationale for the choices made. This study was insider research in which a collective case study approach was followed in order to examine the impact of theoretical

and experiential learning on the development of primary trainee teachers' mathematical PCK.

This chapter highlighted the key ethical aspects considered when conducting the research, and the particular challenges associated with my insider role and the perceived power relationships, including how these were taken into consideration and the effects minimised. A justification for the decisions regarding my methodological choices – a mixed method case study approach – has been provided. This chapter also identified the key lines of enquiry and outlined how the tools of data collection were utilised to enable these lines of enquiry to be investigated. I have provided an overview of the methods in which the data was rigorously analysed, in particular the ways in which themes emerged and were developed across a range of evidence. Additionally I have demonstrated the ways in which I have responded to emerging themes by opening up new lines of enquiry and data collection and analysis. The next chapters explore how trainee teachers develop their mathematical PCK – firstly considering the aspect of school-based support.

Chapter 4 – The School Setting

The thorough process of data collection and analysis explained in Chapter 3 identified five themes in relation to how primary trainees develop their confidence in mathematical pedagogical content knowledge (PCK):

- The importance of support
- The role of reflective practice
- Gaining an understanding of progression in pupils' learning in mathematics
- The importance of the second school placement
- The role of centre-based training in mathematics

These themes will now be examined in relation to the mathematical training and teaching activities that took place within the school setting (Chapter 4) and the mathematics centre-based setting (Chapter 5). There will then follow in Chapter 6 an examination of the inter-relationship between theory and practice, across both settings. Trainees' mathematics development within the school setting is multi-faceted and is influenced by: the range of support mechanisms, the growth of reflective practice and the development of an understanding of pupil progression within mathematics. Chapter 4 is therefore extensive as it explores in turn each of these aspects. Chapter 5 is shorter in length but this should not be seen as an indication that the centre-based setting has less value to trainees. The discussions in Chapter 6 will highlight the ways in which each element of the training year (school and centre-based) combines to enable the development of trainees' mathematical PCK.

When gathering and analysing the data it was important that I considered the degree to which information gathered from the trainees and mentors within the questionnaires and interviews related specifically to the teaching of mathematics and the development of trainee

teachers' mathematical PCK, rather than more generic aspects of trainee development. I was conscious that within primary initial teacher training, and particularly within the school setting, trainees engage with all subjects within the primary curriculum on a weekly basis. Mathematics although an important and usually a daily element, is only one aspect of the extensive range of planning, teaching and assessment experiences trainees engage with. Additionally when considering formal lesson observations completed by mentors during the training year, it needed to be recognised that mathematics was the focus on only a relatively small number of occasions: three out of a total of eighteen observations for EBITT trainees and five out of twenty-six observations for PgCE trainees. With this in mind I needed to ensure that all elements of the questionnaires referred explicitly to the teaching of mathematics (See Appendix F and Q), and that as outlined earlier in Section 3.4.2, I ensured that my interview questions had a clear link to mathematics, and where necessary reminding the interviewees of this if I felt that their responses were becoming generic. When analysing responses I also tracked forward and backwards through the full length of a particular response and/or conversation to identify aspects which led me to feel more confident that the trainee was considering mathematical rather than generic aspects. It should be recognised however that on occasions I could not be fully confident of the explicit mathematical links, but this should not be seen to lessen the relevance of the data or the insight gained, as it should be recognised that many aspects of trainee development are generic across the full range of primary curriculum areas.

4.1 The importance of support

The notion of a community of practice in which trainees learn from knowledgeable others (Mutton et al, 2010, Wenger, 1998), will be explored in this section and the ways in which trainee teachers are inducted into this will be identified, alongside how this in turn supports their mathematical development. The support structure within the school setting, including the mentor, class teacher and mathematics subject leader will be examined in detail. This will focus on support that is provided both formally (a scheduled event such as a mentor or

planning meeting or formally observed lesson) and informally (on a day-to-day ongoing needs basis). An examination of the perceived quality of this support and issues that may arise will be included and this will be linked to the impact on trainees' perceived confidence levels in mathematical PCK. This section will also focus on the observations of good practice within mathematics that took place within the school setting and will identify the ways in which these supported mathematical PCK development.

4.1.1 What are the training and teaching expectations within the school setting?

Before considering in depth the role of the school setting in developing mathematical PCK, it is necessary to outline the teaching and training expectations set by the ITT provider within the school setting. Some of these expectations were governed by the Initial Teacher Training Criteria set by the National College of Teaching and Leadership (2014), whilst the ITT provider determined others themselves. It was recognised that some of the particular expectations of teaching and training in mathematics were likely to be distinct to the ITT provider. However the findings can be said to be generalisable as all ITT courses are likely to show commonality in the type of features present in a training year, including the expectation that trainees:

- Plan, teach and evaluate a range of whole class mathematics lessons
- Are observed teaching mathematics and given feedback
- Have a weekly meeting with an assigned mentor
- Are set targets for development

4.1.2 The nature of the support provided within the school setting

Questionnaires completed in November of the training year were initially utilised as a scoping exercise with trainees on both routes asked to rate the perceived impact of particular aspects of the training year on their development of mathematical PCK. Attitude scaling was used with a 5 point scale (1 = no impact and 5 = high impact), and within analysis it was considered to be significant if the trainee rated the perceived impact as being

higher than average (3), so scores of 4 or 5 were collated. Table 4 shows the results for the elements of the training year that could be seen to have a direct relationship to support provided within the school setting.

Aspect of the training year	% of trainees rating the impact as higher than average (4 or above on attitude scale)	
	EBITT (Sample size = 15)	PgCE (Sample size = 11)
Feedback from observations in mathematics	60% (n = 9)	55% (n = 6)
Observation of good practice in mathematics	67% (n = 10)	82% (n = 9)
Discussions with practitioners, including the mathematics subject leader	47% (n = 7)	55% (n = 6)

Table 4: Trainees' perceptions of the impact of particular aspects of the course on the development of their mathematical PCK.

These elements were followed up within the face-to-face group interviews in order to ascertain the exact nature of the support, why it was considered so valuable in developing mathematical PCK and the ways in which it impacted.

The differences in perceived impact were noted when examining the results from the EBITT cohort. As Training Manager, I was aware that the structure of the different courses meant that a greater focus is placed on the observation of good practice for PgCE trainees at the beginning of the year, with the expectation that they carry out three observations per day during the autumn term. This was due to the fact that trainees on this route usually enroll with substantially less experience within a classroom setting, so the need to observe good practice to gain an overview and reflect upon key aspects of effective teaching was considered to be important. With EBITT trainees, who will have had at least six months experience within a school setting, and usually much more, the expected focus from the outset of the course was classroom practice in the form of teaching, with 50% of the timetable being allocated to this. Although the remaining time was allocated to training activities, with observation of good practice being suggested, this was not required in the

same formal way as the PgCE course. Similarly PgCE trainees were required to formally meet with a range of colleagues, including the mathematics subject leader, as part of autumn term training activities but EBITT trainees did not have the same formal requirements.

What needed to be considered was whether EBITT trainees were disadvantaged as a result of these less explicit and consequently often more limited opportunities. Although they began the training year with substantial previous experience in the teaching of mathematics (See Appendix R) it could be argued that this experience was gained without the in-depth understanding of teaching and children's learning within mathematics that the ITT training year provides. It was only after the trainees had engaged with taught sessions and discussions about mathematics on the course, and had experience of the mathematics teacher role themselves, that they were able to begin to fully understand what they had observed. One EBITT trainee, who had previously taught a lower set in mathematics, described this development in mathematical knowledge and understanding,

'Often people said to me "You've been in school for years." It's not the same thing. I am staggered, absolutely staggered by the things I have learnt this year.' (EBITT trainee 6)

This trainee quantified this indicating that they had "learnt a lot" from working alongside good practitioners, including the mathematics subject leader, who was a strong advocate of mathematics, and her mentor. This in particular enabled her to develop her mathematical pedagogy bringing about an ability to 'explain maths in a way that children can understand, which was a leap [for her] in terms of the subject.' (EBITT trainee 6)

This data would indicate that training opportunities during the ITT year, including observations of good practice in mathematics and formal discussions with colleagues, including the mathematics subject leader, are equally important to EBITT trainees, despite

their previous school experiences, as they will be undertaken with an enhanced knowledge background.

Support within the school setting will now be considered in more detail, beginning with the notion of the community of practice.

4.1.3 The community of practice

During the training year, trainees enter into and join a community of practice (Lave & Wenger, 1991, Mutton et al, 2010) that exists within their teaching practice schools. Once there the routines, practices and expectations of the school will have an enormous influence on the construction of the trainee's identity as a member of the community: first as a trainee/observer and eventually as a teacher. Whilst making this transition learning takes place as the trainee becomes more skilled and knowledgeable as they shape their identity (Lave & Wenger, 1991). This section explores how mathematics lesson observation feedback and trainee observations of good practice in mathematics support their integration into this community - the roles of the mentor, class teacher and the mathematics subject leaders in this process will be highlighted.

It was important to note that the trainee's learning within a particular school community of practice would be heavily situated and likely to be dictated by the school's individual ethos and the way in which mathematics is viewed, as reflected in the mathematics and calculation policies. If trainees are to be able to transfer this knowledge to other communities then they need to be provided with the opportunity to move to other settings for a period of time during the training year so that they can investigate the possibility of the transference of mathematical pedagogical skills. The impact of this second school experience will be explored in depth in Section 4.4. The trainee cohort formed within the centre-based training aspect of the course may also be viewed as a community of practice (Sim, 2006). This community can act as a bridge between the trainee's specific experiences and wider aspects

of mathematical PCK. This was therefore a key component of a move away from the specificity of one setting towards a fuller understanding of teaching in more general terms. This will be examined fully in Chapter 5.

Trainees on the EBITT route were often trained within a school in which they had previously worked as a successful teaching assistant. Although it could be argued that the trainee does not need to be inducted into the community of practice of the school, issues have been seen to arise when schools do not recognise the change of role and expectations that will take place, as the former teaching assistant moves into the role of classroom teacher and is therefore inducted into that community. Interview data highlighted that the trainee may face challenges if the school does not recognise that new skills have to be learned and developed, and that an outstanding teaching assistant or unqualified teacher, who has supported children in mathematics lessons, will not seamlessly become an outstanding teacher. This lack of recognition can lead to too high expectations being set for observations by both the observer and trainee, and the trainee becoming disillusioned and judged to be failing when they do not meet these. EBITT trainee 5, who had previously supported a mathematics set for a year, including teaching in group and carpet sessions, resourcing and planning, described how,

'I found it difficult because I was an amazing teaching assistant and I felt that people expected me to be an amazing student very, very quickly, which I absolutely wasn't because there was so much teaching skill to learn. That is probably pressure from myself to live up to expectation. It's all about how you are perceived.' (EBITT trainee 5)

These expectations can be even higher in cases where the trainee previously fulfilled many of the roles of a class teacher, including the delivery of whole class teaching and/or planning in mathematics (This was the case for 9 of the EBITT trainees in this study – See Appendix R). In these instances there may not be the recognition that the trainee has been fulfilling

those roles without formal training and that for further development to take place, training and support mechanisms need to be initiated. EBITT trainee 6 whose November questionnaire data indicated that she had prior to the course planned and taught a full timetable of mathematics lessons stated that,

'I was an unqualified teacher before I started the course and I found that my head teacher thinks of me as a teacher not a student. I had the expectation that he wanted me to be even better rather than there being a learning process.' (EBITT trainee 6)

For these trainees the four-week experience within a new school was seen as an important learning experience, and a boost to their confidence as they were able to learn and be observed in a new environment where there were no pre-conceptions. This will be examined in more depth in Section 4.4

The support structure provided within these communities of practice will now be outlined in detail.

4.1.4 The support structure

Within this provider key teaching staff within the trainee's school assumed both formally and informally roles in supporting the trainee's development (See Appendix N). The personnel fulfilling these roles may be determined officially by the school or through the choice of the trainee in response to their emerging needs. Hobson et al (2009) highlight that it is important to realise that there will be difficulty in differentiating the impact of so many potential simultaneous contributors to trainees' development. With this in mind, it was important within the interview element of the case study to ensure clarity about whom the trainee was referring to when describing particular aspects of support they received. Specific questions related to the support that the mentor provided were also included to enable the interviewees to become more precise about this particular role. Within this element of data collection it

was important that the focus on support and development in mathematical PCK was maintained, rather than on generic teaching.

In some mentoring models the same person was required to fulfill both the mentor and class teacher role. My professional observation was that the benefit of this was that the person gained a more rounded and in-depth view of the trainee as they worked with them within the classroom on a daily basis rather than just seeing them formally when completing lesson observations or during weekly mentor/trainee meetings. However at the same time it was important that the mentor was able to effectively manage this dual role, and assume the formal position of assessor of the Qualified Teacher Standards when required. It was vital that other people within the school environment were also drawn upon to ensure that the trainee did not receive feedback and assessment from just one perspective, and that judgments were ratified through this process. Within a primary setting it is acknowledged that as it is a core subject area, all primary teachers will usually have had a good range of experiences of planning, teaching and assessment within mathematics, so will be able to offer an insight to trainees. However the level of expertise and confidence may vary. It was therefore important to try and establish the key people within each trainee's setting who were perceived to have had the greatest impact on their mathematical PCK development.

Trainees who worked alongside both a mentor and a class teacher in the study provided evidence during interviews that they were able to distinguish between the different roles that people fulfilled within the school setting,

'My class teacher was more inputting into how I was teaching my maths. But my mentor was there for me and how I reflect and how I could make it better. I quite like having those two inputs.' (PgCE trainee 4)

With their in-depth knowledge of the needs and prior learning of the particular class with whom the trainee is working, and their natural everyday input on the planning process, the class teacher was seen as having a key role in developing the trainee's skills in teaching mathematics lessons on a daily basis. Whereas the mentor's role was seen as key in the refinement of teaching skills, aided by the encouragement of reflective practice. It was this dual support, both aiding the development of effective mathematics teaching, but from different viewpoints that the trainees found beneficial.

Trainees also highlighted how mentors who did not fulfill the class teacher role were able to provide more of an outsider view on their teaching. This was seen as being beneficial as feedback was devoid of emotional attachment to the class and the observer was able to enter the mathematics observation with less of an expectation of how things should be done (Beck & Kosnik, 2000), as they would not have been involved directly in the planning process, leading the trainee to feel more able to innovate.

'I think it is nice having that separate mentor as they are like an outsider who comes in and does it cold. They do not have the emotional thing of being the class teacher.' (PgCE trainee 5)

The precise nature of this support will now be considered in more detail.

4.1.5 Feedback from formal lesson observations

Advice and feedback given about formally observed mathematics lessons was viewed as a crucial part of the development of trainees' learning within the school setting (Edwards & Protheroe, 2003; Mutton et al, 2010). An analysis of data gained from questionnaires completed at the end of the training year in July, showed that this aspect was still considered to have a high level of impact for both cohorts, with 75% (n = 9) of EBITT trainees, and 83% (n = 5) of PgCE trainees rating this aspect as higher than average. Supplementary

information was gained from the questionnaire in response to the question, 'Describe the learning situation which has had the biggest impact on your development as a teacher of mathematics this year?' and this indicated that it was a combination of both positive affirmation of the trainee's progress,

'Receiving positive feedback on my own teaching has resulted in greater confidence in my teaching.' (EBITT trainee 8)

and receiving feedback from expert members of school staff, that impacted on trainee development and confidence,

'I didn't feel very confident teaching the lesson but my mentor [in their feedback] highlighted the good use of resources and the way I taught a particular maths concept in the lesson introduction which catered for all ability groups.' (PGCE trainee 6)

Data gathered from mentor questionnaires also revealed that mathematics observation feedback was an important part of their role, with 100% (n = 15) of PgCE mentors, and 86% (n = 21) of EBITT mentors seeing this aspect as having a higher than average level of impact on trainee development of mathematical PCK.

The identification of the importance of lesson observation feedback in developing trainees' mathematical PCK led me to scrutinise a sample of written trainee lesson observation reports in mathematics. As outlined in Chapter 2.6, research related to the analysis of mentors' written lesson observation reports (Lock et al, 2009; Soares & Lock, 2007; Spear et al, 1997) and discussions (Borko & Mayfield, 1995) highlighted how feedback often focuses on classroom and behaviour management strategies and generic aspects of teaching, rather than highlighting aspects of topic-specific pedagogy and/or subject knowledge. I wished

therefore to examine to what extent this written feedback focused on the development of mathematical PCK (See Section 3.7.4).

An initial analysis of the written feedback revealed that in all reports there was some reference to mathematical pedagogy, ranging from two comments to fourteen. It was the main focus in only four reports, with many comments within the majority of reports relating to class/behaviour management. Where comments relating to mathematical PCK were made they tended to be descriptive in their nature highlighting what the trainee had done and this focus was in-line with research in this area (Edwards & Protheroe, 2003).

'Linked recording back to previous learning – tallying and predicting.' (Lesson report 2)

'Good practical activity involving participation of all pupils – one pupil had to organise the others into size order.' (Lesson report 5)

This focus may have been due to the fact that written observation reports, alongside providing feedback to the trainee teacher, also served as an evidence source for meeting the Qualified Teacher Standards. By making these explicit comments about what had happened the observer was providing written evidence of achievement. For some observers this descriptive commentary also acted as an aide memoire for events when they were recalling key aspects during the oral feedback.

An analysis of interview responses and written observation reports highlighted three key aspects of impact:

(i) The generation of banks of ideas and strategies to utilise within future mathematics teaching. Trainees described the skills their observers possessed in suggesting alternative strategies and ways in which they could approach mathematics. When considering

mentor/trainee feedback discussions following mathematics focused observations PGCE trainee 5 stated that,

'It's having someone else looking at you and saying you could have done this and you could have done that.' (PgCE trainee 5)

Although this approach could be viewed as being beneficial by the trainee as it extends their body of knowledge in regard to strategies and resources that could be utilised in the future teaching of mathematics (Borko & Mayfield, 1995; Crasborn et al, 2011; Mutton et al, 2010), it could be argued that this approach is very closed as it involves the observer imparting their ideas, with the trainee likely be passive in this directive approach (Crasborn et al, 2011). Mentoring is a hierarchical relationship with the mentor being more experienced than the trainee, so this imparting of their knowledge in this way (Edwards & Protheroe, 2003) could be considered to be a natural part of the role, particularly at the start of the training year when the trainee has very limited experience or understanding of mathematics teaching and learning. At the same time if the observer is also the class teacher then their comments and suggestions may be influenced by their concern for the progress of the pupils in the class rather than being an attempt to take forward the trainee's learning (Edwards and Protheroe, 2003). In this situation the observer may be more inclined to offer suggestions that replicate their own teaching style. It could be argued that this directive approach is not the best model as it does not encourage autonomy (Dunne & Bennett, 1997). A reciprocal relationship with the trainee and the mentor engaging in a professional dialogue drawing upon ideas and suggestions from both parties (Crasborn et al, 2011; Edwards & Potheroe, 2003) is more likely to develop skills associated with reflective practice.

At the same time, there were indications that some observers used suggestive phrasing which encouraged the trainee to reflect upon the possible impact of these alternatives, and with a degree of openness in which the trainee was able to choose whether to implement the

approach in future teaching. This role as an initiator who brings out information (Crasborn et al, 2011) could be seen as being beneficial as it allowed the trainee to engage in a more active way in the conversation. EBITT trainee 1 highlighted the value of this approach following an observation conducted by the mathematics subject leader,

'There was an observer who said, "Have you thought about what it might have looked like if you had done it this way? It's saying, "What about this?"' (EBITT trainee 1)

There was also evidence of this approach within the mathematics written observation reports. In all but one instance these were phrased as questions with the mentor making an implied suggestion rather than stating what could be done.

'Are some children ready for this – maybe use multiplication as repeated addition or resources to support times tables?' (Lesson report 15)

'You could try doing $8 + 0$ on the calculators to demonstrate what they are saying isn't mathematically correct.' (Lesson report 12)

Strong and Baron (2004) noted that mentors were more inclined to utilise indirect suggestions within their conversations and that this was likely to generate discussions centred around the idea, as trainees felt that there was more freedom to do so. However, as the proposal was made, the trainee may feel obliged to implement it in order to seek approval and positive feedback in the future (Rozelle & Wilson, 2012).

(ii) Feedback on positive aspects of the lesson and targets for future development. Trainees described the value of receiving information about what had been successful within a lesson, and how this impacted positively upon their confidence level when teaching mathematics.

'The situation that has had the biggest impact on my confidence was completing my unit of work in mathematics [Planning, teaching and assessment of a designated sequence of five lessons]. I was observed by the head of mathematics and my feedback was very positive. I think that this reassurance from a senior figure boosted my confidence the most. This confirmed that my planning, teaching and progression of learning was good.' (PgCE trainee 5)

This aspect of psychological support in which the trainee was given confidence through recognition and encouragement (Hobson, 2009; Mutton et al, 2010), was seen as an important element within the support structure. In some cases trainees indicated that they were sometimes harsh on themselves, and the observer was able to put things into perspective, seeing the bigger picture and the trainee's progress in relation to their stage in the training year

'Sometimes it is easy as a practitioner to get really negative because you feel that you didn't have the outcomes that you wanted. But to have someone to say that what you did here was really good.' (EBITT trainee 2)

Alongside this the trainees recognised the value of the identification of areas of weakness and specific targets to aid future development, seeing *'Identifying and supporting with areas of development'* (PGCE trainee 6) as being an important aspect of the mentoring role.

However in order for continued development to occur a degree of appropriate support and challenge is also vital (Daloz, 1986; Tang, 2003). This was apparent in the trainees' comments,

'If they give you 2 points to work on for the next time then you can take that with you and you work on that...It is really easy to improve really quickly.' (PgCE trainee 2)

Mentors described this role offering both support and challenge as that of a critical friend,

'Supportive as you said, but also a critical friend that they can come to. By critical friend I mean that you are going to have expectations that they will develop along this way. As a mentor you want them to be independent but actually you are looking after them. I think a lot of the students need that reassurance and they need their confidence boosting. And they just fly. They get to a certain stage and it's I can do it.' (Mentor 1)

However if the observer was overly critical then this could be overwhelming and stunt progress (Mutton et al, 2010). Although the majority of trainees reported on positive aspects of mathematics observation feedback, some trainees experienced situations that impacted negatively on their development and confidence level.

'She didn't say anything positive ever. It was more robotic – you didn't do this and you didn't do that. I didn't like this approach because whatever I said wasn't taken in either.' (PgCE trainee 5)

At the same time, there was evidence that this negativity was utilised by the trainee in order to make them stronger in their determination to prove that they were able to succeed,

'When she came to see my lesson [within my planned mathematics unit of work] she ripped my lesson apart. I remember feeling so downtrodden, so disheartened and that was one of my nights of many tears. However it made me stronger.' (EBITT trainee 3)

EBITT trainee 3 described this experience spurred her to look carefully at the planning for the sequence of lessons. Through this she was able to see what was wrong and came away with the realisation that *"I can do this"*.

Trainees also highlighted the need for targets to be manageable and that if the observers focused on too many areas for improvement then this could become unmanageable and limit progress,

'She gave me so much feedback, 20 bullet points I needed to work on, but it was just too much...The year leader came in and said you just need to focus on two things. From then my maths really improved. My areas were modelling and questioning.' (PgCE trainee 2)

It could be also questioned whether the targets set were effective in developing the trainees' mathematical PCK. At the same time there was evidence in-line with research (Lock et al, 2009; Soares & Lock, 2007 Spear et al, 1997) that targets focused on general classroom management rather than specific mathematical aspects

'I think they are quite general. The maths group I have in year 5 is quite chatty and it was about behaviour and managing that side of things.' (PgCE trainee 4)

The scrutiny of targets recorded on the written mathematics observation reports often revealed weak links to mathematical PCK. Targets were set in all but one instance, but the main focus of these was mainly general pedagogy. In three cases high quality mathematical targets were set:

'To know how to break down mathematical processes to first stages to ensure all understand' (Lesson report 3)

'To ensure that there are suitable resources to enable pupils to achieve – to use formal methods without having to know times table facts' (Lesson report 14)

'To include open questions for challenge, i.e. the answer to $? \times ? = 248$.' (Lesson report 27)

During the interviews trainees provided some insight into a possible explanation for why mathematical specific subject aspects are not highlighted in observation reports, stating that,

'I think with observations there is a form to be filled in and it does say about subject knowledge but in my previous experience they have glossed over that a bit. They have said it is good and then moved on. (PgCE trainee 5)

The reasoning behind this could be related to a comment made by a mentor during the group interviews:

'The [mathematical] subject knowledge is very obvious when you observe a lesson. If it is good then it comes across and if not it is a specific target that would be picked up fairly quickly.' (Mentor 2)

Mentors are able to set subject specific targets in relation to issues and deficits within mathematics lessons but are less confident when setting targets in order to challenge the trainee. This data highlights that when trainees enter the latter stages of the training year and have mastered the basic skills in effective mathematics teaching, they may not be challenged to move onto a higher level, as observers tend to operate on a deficit model, focusing on areas of weakness rather than advancing areas of strength.

(iii) Opportunities to engage in reflective dialogue. In several instances the trainees described the ways in which feedback following observations allowed them to reflect upon their own progress in teaching mathematics.

'I like having the dialogue as it really helps me reflect over it in a different way than I would do in my mind.' (PgCE trainee 5)

This process was an important element of the overall development of learning and reflective practice (Crasborn et al, 2011; Mutton et al, 2010) and was valuable as unlike written reflections this participatory version of learning (Edwards & Protheroe, 2003) could be skillfully managed through the observer's use of questions,

'They are questioning you and you are thinking, "Oh yes that's where it went wrong, or that's where I missed using mathematical vocabulary, or that was really good." It makes you more critical of yourself.' (PgCE trainee 4)

This linked to Malderez and Bodoczky's (1999: 19) view, that the mentor's role within observation feedback is that of 'holding up a mirror' so that the trainee is able to see again, or differently the events of the lesson. Through this, and with the mentor's support, the trainee is able to begin to develop and extend their understanding of effective mathematics teaching. This best practice however was only evidenced within one mathematics written report:

'Is there an efficient way for each group to collect data? Collecting data from children is notoriously difficult. Have a think about this for any future data collection activity.

What else could you have done to collect the data?' (Lesson report 10)

However the written mathematics observation reports may not provide a full picture of the feedback that was given, as the process is likely to be elaborated upon within the discussion element. At the same time though they are a valuable document as they were aimed as an aide-memoire for the conversation, and provide a record for the trainee to look back and reflect upon following the observation. The inclusion of questions, in particular those that are mathematics subject specific, as part of the reflection process by the observer could be a good addition to the document.

Excellent practice in feedback was indicated where the trainee felt that the mentor was able to utilise analytical skills within the feedback process in order to consider how a child's difficulties when playing a coordinate game could have been addressed more effectively,

'My mentor at my base school was excellent. She would really analyse the good bits and also analyse how you could have done this here.' (PgCE trainee 5)

This process in which the mentor provides their interpretation of events could be viewed as supporting the trainee's capacity to scrutinise and respond to their own teaching and gain an understanding of how pedagogic decisions are made (Edwards & Protheroe, 2003).

Mentor interview data similarly highlighted the importance of a supportive role in which the trainee was guided towards improving their own practice through reflection. In this, the role was seen as that of a facilitator.

'As a supportive role. To be there for the trainee and any of their needs. More of a facilitator for them and to actually support them in that way. I do ask the trainee lots of questions rather than just tell them – I think that is really important. To encourage them to be really reflective is one of the most important things.' (Mentor 2)

4.1.6 Observations of good practice in mathematics

The opportunity to observe and discuss the practice of experienced teachers of mathematics was seen as being an important part of the development of trainees' learning within the school setting (Beck & Kosnik, 2000; Pinder, 2008; Malderez & Bodoczky, 1999). An analysis of data gained from questionnaires completed at the end of the training year in July, showed that this aspect was still considered to have a high level of impact for both cohorts, with 67% (n = 8) of EBITT trainees, and 100% (n = 6) of PgCE trainees rating this aspect as

higher than average. Supplementary information was gained from the questionnaire in response to the question, 'Describe the learning situation which has had the biggest impact on your development as a teacher of mathematics this year?' and this indicated that trainees valued the opportunity to observe experts within the field of mathematics whilst in their school, including subject leaders, and that observations often focused on identifying aspects of good practice which they could then apply to their own mathematics teaching.

Questioning within the interview element of this study aimed to investigate further the trainees' perceptions of (i) the purpose of mathematics observations, (ii) what they gained from them and (iii) the ways in which these observations impacted on their own practice in regard to mathematical PCK.

Research suggests that it is important that trainees are provided with the opportunity to see theory and ideas that they have learnt within centre-based training put into action within the classroom (Beck & Kosnik, 2000; Pinder, 2008). This allows them to make reflective judgments about which aspects will be useful and relevant within their own particular setting. The trainees also recognised that observations may also provide other ideas not encountered during input from the mathematics tutor,

'I think it can be overlooked – observations of good practice. Why it is so crucial is because the maths tutor can show us what works for her, but by going out and seeing other teachers and then putting them into practice, you are opening your world to the possibility of other things. She [the maths tutor] is so experienced and it is great but she doesn't know every teacher's approach to doing things.' (PgCE trainee 4)

This demonstrated the trainees' desire to gain additional ideas and teaching strategies within mathematics as a result of the observations that they complete,

'It gives you an extra tool and you think "I didn't even think of that!" Let's magpie that. Let's steal that idea and put it into practice. By seeing better and better practice and going to see the maths specialists and how they do it...gives you a broad spectrum of ideas.' (PgCE trainee 4)

This reflection on good practice and the application to the trainee's own practice was further illustrated by EBITT trainee 8 who stated that,

'I observed Year 6 maths (taught by the subject leader). There was lots of discussion about the methods the children had used. Eventually the teacher coaxed a general rule from the pupils which became the success criteria for the independent tasks that followed. The following day in EYFS I asked the children, "What do we do?" and turned this into 2 secrets of success which we referred to constantly for the rest of the week.' (EBITT trainee 8)

Trainees also recognised the importance of linking key aspects of learning gained through their observations of good practice, to their work towards achieving their own personal target achievement. Targets were given greater meaning if the trainee was able to see the positive impact of the pedagogical approach for himself or herself,

'Being in Foundation Stage and Year 1 it was modelling that was the good practice, so I have now made the focus of my maths that I model correctly. If the children go off [to independent tasks] competently then I know that I have modelled well.' (PgCE trainee 3)

The importance of seeing a variety of practitioners was also an important feature, and with this came the realisation that the teaching of mathematics can be approached in a range of ways,

'I watched a lady from Every Child Counts who was really good and she gave me loads of good strategies. She had lots of good ideas because what she was doing was practically based and not worksheets.' (PgCE trainee 1)

In order to be successful mathematics teachers, trainees need the opportunity to both examine their own beliefs about how the subject can be taught and engage with alternative images (Borko & Mayfield, 1995; Feiman-Nemser, 2003, Nicol, 1997), often ones quite different from their memories of their own schooling. PgCE trainee 1 described how her perceptions were dispelled through the observation of good practice,

'My memory at school was sitting there, writing things down and not really doing things. I think when I got into teaching I saw loads of different ways you can teach maths, like being practical. Them doing things is what I think did it for me. It is not boring but is actually quite fun. Once I got into school it was very different from my memory.'

This opportunity to see aspects in a different light was particularly important in the subject of mathematics as trainees often come into teaching with negative views as a result of their childhood experiences of the subject – feelings of failure and inadequacy (Borko & Mayfield, 1995; Britzman, 2003; Mutton et al, 2010). This was reflected in comments by PgCE trainee 3,

'I've got over that now, but I do think that you do hit that wall when your first start being a teacher. My experiences had been very negative. My bad experience came in secondary rather than primary school. Primary school maths was good and you get turned off it in secondary school.'

Alongside centre-based experiences and positive experiences of teaching mathematics, the observation of good practice can support a change in perception,

'I never thought I would enjoy teaching maths but I really do. I think I prefer teaching maths to English.' (PgCE trainee 1)

Pinder (2008) refers to a process of osmosis where trainees observe and take in what they want and then change it into a form that is relevant to them. This selective process was seen strongly in the trainees' responses with them providing a clear indication that the aim of observations was not to lead to mimicking of the teacher (Loughran, 1997) but included a degree of decision making in regard to how to best incorporate a range of practice into their own mathematics teaching. EBITT trainee 2 highlighted what they had gained from being able to observe the mathematics coordinator,

'You feel a real triumph when you can take something you have seen and put it into practice. You feel really proud that you have been able to interpret something and mould it for your own class.' (EBITT trainee 2)

Trainees were aware that they had their own style and preferences in regard to the mathematical PCK,

'My class teacher teaches set one and she's a mathematician and she has a mathematical brain. The person I am being mentored by is amazing in a completely different way – very creative and holistic. Being able to see both of them and see how they both work and get results has been very helpful. I don't think I am as a creative as that one, or as mathematical as that one but I know I can put myself in the middle and still get the children to the standard we need.' (EBITT trainee 5)

Additionally, the observation of less than good practice in the teaching of mathematics was highlighted by the trainees, with some recognising that this could limit their scope for development,

'If you are only seeing satisfactory practice, then you are going to possibly mirror that as you don't know what is out there.' (PgCE trainee 4)

The best practice was where trainees were provided with the opportunities to observe mathematics specialists, as this ensured that they were able to see creative and innovative approaches, and a passion for mathematics,

'Some teachers are more confident in some subjects. Some love maths and are really good at it, and obviously have loads of different ways of teaching it. Whereas others think, "Oh it is maths" and just do the basic things.' (PgCE trainee 5)

At the same time it was interesting to note that some trainees felt that they could also learn from observing less than good practice. They were able to make comparisons with the good mathematical practice that they had seen (particularly if they had seen another teacher with the same class), and were able to analyse what made the difference and the impact on the learners,

'I think you think, "I will not do that." You can see the direct impact it has on the children and their learning and it makes you go, "Okay, don't do that." I think that if you can easily spot it then that has a bigger impact on you than seeing good practice.' (PgCE trainee 2)

This was also recognised by the mentors who felt that observation was important in the early stages of training year and that it was linked to the development of reflective practice,

'It is not always seeing a really good lesson but also seeing lessons that aren't so good. They can then think that didn't work well and they start reflecting already.' (Mentor 1)

Research (McIntyre 1988, Mutton et al, 2010) suggests however that this ability to identify and reflect upon the impact of both poor and good teaching on learning is a skill that develops as the trainee becomes more familiar with the notion of effective teaching, something that may not be there in the initial days of the training year

Mentors acknowledged that this depth of understanding is developmental, but suggested that this may be at a higher level initially if the trainee had already spent some time working in a school setting – with many teaching assistants in primary schools being appointed to support groups and/or individuals in the core subject areas, including mathematics (See Appendix R),

'It depends where they have come from as well. If they have been a teaching assistant in a school they have seen so many lessons that they can compare them. If they have not been in a school very often then I think it is much more difficult for them to say that was a really good lesson because they have nothing to compare it to.' (Mentor 2)

This prior experience is something that needs to be taken into consideration but the ability to compare lessons and say if one is better than another is only an early stage of understanding good practice. If a trainee teacher is to be able to reflect on why something is effective and link this to pupil learning, then this has progressed onto a higher level. The mentors suggested that this was something that can only develop over time,

'They have to get into their minds that it is what the children are learning in the lesson and not "That teacher is very good at presenting something."' (Mentor 2)

With this in mind it is important that trainees are provided with opportunities to formulate a view of good mathematics teaching in the initial stages of the training year, but that this opportunity does not cease once they become more experienced. It is in these later stages that trainees begin to understand more fully what they see in relation to pupil learning and know what they need themselves to learn.

Although it was recognised that observation of good practice can enable a trainee teacher to develop a repertoire of effective teaching skills in mathematics, for this learning to be truly effective and long-lasting, the trainee must also develop an understanding of why the impact on pupils' learning has been brought about. The trainee needs to have the opportunity to delve into the mind of the teacher being observed and explore the reasoning behind the pedagogical decisions that they made, both prior to and within the lesson (Pinder, 2008; Zanting et al, 2003). The trainees' opportunities to engage in this type of learning dialogue varied, with it appearing that the better teachers were more willing to do so,

'If I had questions, or they were quite good, or if there was something really relevant that they should point out, then she would explain why she did certain things.' (PgCE Trainee 2)

Additionally, trainees were also seen to take advantage of opportunities for informal observations and dialogue, stating that this was *'good because we do maths every day'*. (PgCE trainee 1). This frequency provided trainees with opportunities to analyse pedagogy and pupils' learning in mathematics over a short time-scale.

At the same time it was necessary to acknowledge that the demands of the primary school meant that many class teachers and mentors had very limited time to engage in additional trainee-focused activities outside of their day-to-day pupil teaching commitment (Hudson & Hudson, 2011). Conversations were more likely to happen if the trainee observed the class teacher as they would be in the classroom setting before and after the lesson. The value of

pre-observation discussions was highlighted as being particularly beneficial as this provided an opportunity for the trainee to gain awareness of what was likely to happen prior to completing the observation – so knowing what to look out for,

'Before the lesson she said that this was what she was going to be doing, and using these resources and look for this. This made it a lot more apparent to me.' (PgCE trainee 1)

Research (Edwards & Collison, 1996; Hobson et al, 2009), suggests that experienced teachers can find it challenging to articulate their practical knowledge in mathematics both as a result of skills becoming embedded in everyday natural practice and as classroom life is so unpredictable they are constantly having to respond in-action to complex situations as they arise. The mentors in this study suggested that the culture of accountability for pupils' learning and the cycle of professional development observations within schools has made them more able to articulate their decisions in relation to mathematical PCK but that it was something that they needed to make a conscious effort to do,

'I find it okay as you are reflecting and adapting things as you go along within the lesson, but you have to make a mental note that's why I did it so you can feed back.' (Mentor 2)

This data highlights that mentors should value post-observation discussions being willing to allow time for such discussions, and that trainees should be provided with the necessary skills to enable them to pose appropriate questions in order to facilitate access to teachers' practical knowledge in relation to mathematical PCK. School management teams should also ensure that they provide specific time allocated to the mentoring role, so that there is a dedicated weekly opportunity for these discussions to take place.

4.1.7 The role of the class teacher

Formal and informal discussions with a range of practitioners within the school setting, including the mentor, class teacher and subject leader for mathematics were rated higher than average by 72% (n=13) of the trainees. The important role that the class teacher fulfilled in supporting the development of mathematical PCK in the school setting will now be examined.

Additionally, the class teacher was often highly valued amongst trainees as they provided daily on-going support in the teaching of mathematics (Gut et al, 2014). This included informal feedback on lessons taught; opportunities to observe the modelling of teaching strategies (Gut et al, 2014); use as a sounding board for ideas (Borko & Mayfield, 1995) and the provision of advice. For several trainees the support of the class teacher was valued more than that of the mentor, with PgCE trainee 3 stating that, *'I think the class teacher developed me more as a maths teacher.'*

One reason for this high level of impact was the fact that the class teacher was able to provide specific advice on the mathematical learning needs of the class of children the trainee would be working with. This level of knowledge would not necessarily be available to the mentor in the same way,

'It's my class teacher who knows the kids inside out, and it is my class teacher who is teaching [them] herself and she can say "Why don't you try doing this which I have done with them?"' (PgCE trainee 2)

It is this specificity of information about the children's learning needs and the suggestions of tried and tested pedagogical approaches in mathematics that are heavily situated in the class and school setting, which the trainees in the beginning stages of the training year

found valuable (Edwards and Protheroe, 2003). The shared responsibility of the class and the learning of the children, whether it is for the long or short term, meant that the class teacher had a vested interest and felt a keen responsibility in ensuring that the trainee was well prepared and supported for the teaching of mathematics lessons (Gut et al, 2014). The planning process was seen as a particular aspect in which the class teacher could provide valuable guidance, either working alongside the trainee,

'The support in school has been excellent – sitting with the teacher learning how maths is delivered and looking at plans, adapting plans and working with a year 2 class with a range of abilities.' (EBITT trainee 4)

or through the provision of feedback and advice once the mathematics lesson had been planned. PgCE trainee 4 described how after undertaking the planning process in which the mathematics centre-based training notes and a scheme of work were used, she was

'Going to the class teacher for guidance and saying "This is what I've got, do you think this is suitable or do you have suggestions?"' (PgCE trainee 4)

Advice given within the school setting can immediately be put into practice and this was seen as enhancing its value (Edwards & Collison, 1996).

At the same time, this shared responsibility could be seen to constrain or put additional pressure on the trainee, as they may feel that they have to replicate the pedagogical approach of the class teacher and therefore not have freedom to innovate (Beck & Kosnik, 2000; Mutton et al, 2010; Pinder, 2008). This could be said to be particularly challenging for PgCE trainees as they are only with a class for a six-week teaching practice block so never really feel ownership of the class,

'Sometimes I am still thinking I am teaching someone else's class. I still think what are they thinking and what would they do? They are probably thinking I would have done something different.' (PgCE trainee 1)

Trainees expressed that they wished for the freedom to teach the class without the presence of the class teacher as this removed some of this pressure,

'I just wish they would go away. I asked my class teacher to leave me alone, in a nice way.'
(PgCE trainee 3)

It was clear however that trainees took this shared responsibility seriously and that the desire to advance pupils' learning led them to plan carefully pedagogical approaches for the teaching of mathematics. EBITT trainee 3 highlighted how the opportunity to watch an outstanding teaching of mathematics for a period of time was good and that the impact of this was,

'When I had to teach them I had to make sure I gave them the equivalent challenge.' (EBITT trainee 3)

Trainees may be inclined to mimic and follow the class teacher's script within the early days of teaching (Pinder, 2008; Rozelle & Wilson, 2012). Although this may provide the trainee with success and positive feedback in the early days, it was important that the trainee recognised the need to move away from this and find their own teaching style and pedagogical approach,

'I find myself using the teacher's voice – I was speaking like them. I was "Stop it, stop it!"'
(PgCE trainee 3).

At the same time, good practice in pedagogical development was where the class teacher encouraged the trainee to experiment and take risks in their teaching (Pinder, 2008). The success which was experienced when trainees followed an independent approach to teaching, led to enhanced confidence levels. EBITT trainee 3 describes the impact of,

'Sharing a maths set with the deputy head teacher, a very experienced, motivated leader, with a passion for children and a deep understanding of maths...She activates my self esteem enough to set me off, gives me constructive feedback and exposes me to new things all of the time – everyday.' (EBITT trainee 3)

For trainees to develop a strong pedagogical background and confidence in their own approach to teaching mathematics in this way, the class teacher and/or mentor has to develop their role according to the stage of trainee development. In the early stages they should act as a model in both planning and teaching in mathematics, and be open to discussions about their pedagogy. As the trainee develops they should also be willing to offer them the freedom to initiate their own ideas within the classroom; offering them advice and feedback when requested but also moving outside of the classroom so that the trainee is able to make their own decisions as the lesson progresses. Success experienced in this way leads to gains in confidence. Mentor 1, who at the same time fulfilled the role of class teacher with her trainees, expressed this ideal,

'You want them to be independent but actually you are looking after them. I think a lot of the students need that reassurance and they need their confidence boosting. And they just fly. They get to a certain stage and it's I can do it.'

4.1.8 The mathematics subject leader

The most effective approach to trainee development could be seen as one of engagement (Tang, 2003), in which the school is able to provide challenge and support through the

provision of opportunities to engage with groups of professionals across the wider school community. The trainee may be encouraged to initiate this engagement, although mentors stated that they saw the signposting of such opportunities as part of their role, including *'liaison with good/outstanding maths teachers'* (Mentor 4). Gaikhorst et al (2014) advocate an integrated professional culture within schools in which trainees' development is taken seriously by all and a range of colleagues are willing to be involved in collaboration.

A range of EBITT trainees mentioned that links made with the subject leader in mathematics had a positive impact on their development of mathematical PCK and their confidence levels. As EBITT trainees are trained within the same school for the majority of the training year, they will have the opportunity to form stronger and more established links with members of the wider school community.

Support with identifying and planning for pupils' misconceptions in mathematics was a strong feature of the particular support provided by mathematics subject leaders,

'It is picking up on the misconceptions. He'd spot the things that they'd misunderstand and why. He is a maths specialist. I have learnt a lot from seeing him do that, and now I do that as well.' (EBITT trainee 6)

It was also recognised that the mathematics subject leader was often the person who would display the best practice in pedagogical approaches within their teaching, and this would often replicate areas that had been explored within centre-based training,

'We've gone back to using more concrete representation in our school. The maths coordinator is doing a masters degree and so she has become a real advocate of it.' (EBITT trainee 6)

In this way the trainee was further supported in formulating a view of good teaching within mathematics.

It was also noted that the mathematics subject leader also provided a supportive role in terms of planning, being able to suggest additional ideas for teaching,

'We have a strong maths coordinator and whenever I had planning that I was dubious about I would always take it to her and she would give it the once over and say, "Have you thought about this?"' (EBITT trainee 2)

In this instance the trainee recognised that the school as a whole was strong and supportive so seeking the advice of colleagues was encouraged. They also highlighted how this support was not required once their level of experience developed and that this gave them a strong sense of achievement,

'For me my confidence grew as I had to take less and less plans to her, and I was ready to fly the nest.' (EBITT trainee 2)

For other trainees however the support from the mathematics subject leader was provided when lessons had been less successful, and as part of the reflective process they were seeking advice. It was recognised that as a trainee teacher there would be gaps in pedagogical knowledge due to lack of experience and that the subject leader would be able to address these gaps,

'I've made a relationship with the maths leader. She is a massive ambassador for saying that you have to go back to the basics. Get things out and make it really tangible. You then see the progression in numeracy. Most of my learning has come from that person and me

saying "I need to do that differently or what about this?" Or I want to make sure I am doing this correctly." (EBITT trainee 5)

Where the school offers a supportive and open community for trainee teachers, they are able to utilise a range of expertise, appropriate to their particular needs and the situation they are working within. The opportunity to engage with a range of practitioners enables the trainee to move away from the specificity provided by the class teacher, and ensure that they are able to draw upon the best practice in mathematical pedagogy available to them. Implicit to this is the process of reflection and this will now be explored in detail.

4.2 The role of reflective practice

A key component of mathematics training and teaching within the school setting is the opportunity to engage in reflective practice. This aspect will now be examined in detail, including the identification of the ways in which trainee teachers engage in this process and how this can be linked to perceived confidence levels in mathematical PCK. The ways in which the trainees' approach to reflective practice changes during the training year will also be identified.

Reflection is viewed as a deliberate cognitive process by which a person notices a particular situation or concern, and puts into action a response (Gibbs, 1988; Lane et al, 2014). The response itself may come as part of the event (in-action) or following it (on-action) when the person steps back and considers the situation as a whole (Schön, 1987). The value of engaging in reflective practice when learning to teach is widely advocated (Hagger et al, 2008; Loughran, 1997, Moon, 2004). This is based on the belief that long-lasting and meaningful professional development will occur if the trainee is active in their own learning and the decision-making process (Loughran, 1997; Malderez & Bodoczky, 1999). Trainees could be seen to benefit from a directed approach to reflection (Orland-Barack & Yinon, 2007), in which the training provider sets specific requirements that encourage and support

the reflective process. The trainees highlighted this as being beneficial, as the expectation for the completion of the mathematics thematic and weekly logs and lesson evaluations, *'gets you into the habit all the time,'* (PgCE trainee 5), and encouraged trainees to think about how their teaching could be improved. The short-term aspect of this study meant that it was unclear whether this was a life-long skill that had been developed, or whether this would diminish once the trainee was no longer being formally assessed by the documentation they are completing (Loughran, 1997). However there was evidence that reflection did for some become embedded into their everyday practice, *'It becomes a natural process that you do straight afterwards.'* (PgCE trainee 5).

Data gathered from trainees' questionnaires at the end of the training year highlighted the impact this aspect had on their development of mathematical PCK, with 78% of trainees rating its impact as higher than average. Mentors also highlighted the progress that trainees made in reflective process across the training year and the importance of this,

'The reflection you see from a trainee is amazingly developed from when they first come in to when they complete the last practice. It is fantastic to be able to do that as you have to be able to do that as a teacher' (Mentor 2).

During the analysis stage of this study I was able to identify a range of key words and phrases that trainees utilised when describing the reflective process that they undertook. Alongside the explicit reference to 'reflection', I also chose to associate the following terms to reflective practice:

- Trial and error
- Learning from mistakes
- Changing things for the next lesson

- Revisiting
- Finding own style

Many of the trainees highlighted the ways in which a trial and error approach (Schön, 1987) involved them in identifying negative aspects of their teaching and as a consequence reflecting upon measures they could take to improve their practice in the future. When asked how they developed their knowledge of progression in mathematical concepts EBITT trainee 7 stated that,

'Practice makes perfect. Trying it out and finding out it didn't work and thinking I am teaching that again and I need to make sure they know that before I start.' (EBITT trainee 7)

This included developing an understanding of the sequential nature of mathematics and that for the children to be successful, the early stages need to be secure before later elements can be tackled,

'Don't move on unless the basics are secure. For me it was realising that there was no point me attempting addition and subtraction on a number line if they couldn't do more/less.' (EBITT trainee 15)

In instances where things had not gone as expected there was evidence that the trainees drew upon a range of sources to support their reflections and to enable them to formulate solutions. This included discussions with other practitioners within the school, including the mathematics subject leader and mentor, and also referring to notes from mathematics centre-based training sessions. However they were aware that experience had an impact on their reflective practice, with them becoming more proactive and adept at quickly realising when and why things had not gone well. They also recognised that the solution to an issue may not be achieved following just one reflection and adaptation, but that real progress may

only be seen after a sequence of lessons and experimentation with a range of pedagogical approaches,

'I could see that this was a difficult mathematical concept for the children to grasp. I had to adapt my planning several times and repeat a few lessons in order to develop the children's understanding of time. This was challenging as I had to experiment with different resources and teaching strategies.' (PgCE trainee 7)

This development of a repertoire of experiences and knowledge, which they could draw upon within reflections, was linked to pedagogical confidence in mathematics,

'Now I feel confident that tomorrow I am going to ignore the lesson I had planned and readdress it – having the confidence to realise and reflect.' (EBITT trainee 2)

PgCE trainee 2 likened this process of gathering pedagogical experiences to building blocks, with trainees, *'Starting off with a few and you don't ever lose that groundwork.'*

Trainees recognised that it was not only negative situations that provided the source of reflections, but that successes could also be utilised to take forward pedagogical development. This creation of a repertoire of successful approaches in mathematics may be supported by the mentor in the initial stages of the training year as trainees recognised that they can often be harsh on themselves if the outcomes are not as good as they would have wanted. Mentors themselves recognised their important role in the reflective process both in *'helping the trainee to reflect on their mathematics teaching'* (Mentor 5) and providing them with the opportunities to *'Try things out and make informed decisions about what can work or not, and what went well.'* (Mentor 6)

There was evidence that changes in reflective practice emerged as the training year progressed. The process of experimentation followed by reflections was seen as an important aspect of the trainee developing their own pedagogical style. When asked to consider the process they go through when planning a mathematics lesson and deciding on the appropriate pedagogical approach, PgCE trainee 5 reflected that,

'That's part of it – the whole course – you find your own style that you were probably not aware of and didn't know particularly in the beginning. Something's work for you and something's don't.' (PgCE trainee 5)

By drawing upon a range of sources of advice and support, and through experience, the trainee was able to discover the approach that was best for them.

Schön (1987) highlights reflection that takes place in-action, where a teacher is able to reflect in the midst of an event and then as a consequence make changes immediately to alter the course of the lesson for some or all of the children. The nature of this form of reflection has however been questioned with critiques suggesting that the fast pace of a lesson means that teachers seldom have time to reflect, so successful alterations to lessons are likely to be as a result of luck, pre-meditated planning (Mason & Spence, 1999) or merely thinking rapidly on their feet (Eraut, 1995). Within the classroom as the teacher is working with children with individual needs the number of potential variables will make the pre-establishment of set events for a lesson challenging, and teachers need to react on the spot as contextual knowledge is developed (Bednarz & Proulz, 2009).

Data gathered from trainee interviews indicated that they do go through a process by which they note that learning is not progressing as expected during a lesson and that as a consequence make changes to their pedagogical approach. For EBITT trainee 2 this was a

key difference they recognised between their previous role as a cover supervisor, taking whole class mathematics lessons, and their role as a trainee teacher,

'That was a lesson I needed to learn – the ability to recognise when a plan needed to be adapted on the spot. To realise that these children are not getting this and to bring it back in a mini plenary or let's go over it again as the children are not getting it.' (EBITT trainee 2)

Within this instance, however, the level of reflection may have been minimal as the trainee could be seen to be responding to the issue of the children not understanding in a set way – by revisiting teaching that has already occurred within the lesson. It was positive that the trainee was able to recognise that there was an issue and has been responsive to this, but their pedagogical knowledge will not have been challenged as a result of the change of events that have occurred. At the same time there was evidence of higher-level responses to pupils' difficulties, with the trainee drawing upon their knowledge of progression in pupils' learning in order to adapt the approach they were taking within the lesson,

'I can think of a few lessons where I thought about 10 minutes in, "Okay I am going to have to change this whole thing, either to move up or down.' (PgCE trainee 2)

This type of reflection was seen as being challenging in the initial stages of the training year as trainees may have recognised the problem, but not have the knowledge to put changes into action on-the-spot. This was highlighted by the mentors who recognised that,

'They can perhaps reflect upon it afterwards but being able to do it there and then that just comes from experience. I think you have to have the experience there to be able to do that and change something within your lesson. Confidence in their teaching ability to be able to do that...by the end of the teaching practice you have been able to see that they have gradually begun to build that into their teaching.' (Mentor 2)

In the later stages of the course, through a combination of experience and information gained from centre-based training (Malderez & Bodoczky, 1999), the trainees were seen to develop both the knowledge and confidence to implement this form of adaptation within lessons. This immediacy of action was seen as a sign of a being a better teacher by the trainees. Although there was still some indications that these actions involved thinking quickly on their feet (Eraut, 1995),

'Actually when you are having to do it in action you don't have time to think about it, you just do it.' (PgCE trainee 2)

Rather than a negative aspect however, this data could be seen to indicate the trainee's confidence and growing natural ability as a mathematics teacher, with the trainee being able to act instinctively in response to issues within lessons,

'Now I feel that I would know when they are not getting it. I think you do it and don't actually realise until afterwards, and you think I didn't do that I did something different.' (PgCE trainee 1)

Although this reflection in-action could be said to be an indicator of the trainee's confidence level, several trainees highlighted how they felt constrained in making changes when they were being observed. This was related to their awareness that they were being assessed and that deviation from original planning could be seen as a failing,

'You feel that you are going to be criticized for abandoning what you have planned to do and taking a different tact. It is like, "She did not think this through and is doing something different." But on my own I think this isn't working...break it down a bit.' (EBITT trainee 6)

Mentors should encourage their trainees to have the confidence to respond in-action to the pupils' needs, and provide trainees with the opportunity, through their reflections in feedback discussions, to analyse and justify why particular decisions were made. Data in Section 4.1.5 highlights that these in-depth discussions do not always take place following formal mathematics lesson observations. Training opportunities, facilitated by the ITT provider, could develop mentoring skills in this area with the aim of enhancing both the quality of feedback related to mathematical pedagogy and reflective practice.

4.3 Understanding pupil progression

Analysis of data identified links between the trainees' understanding of pupil progression in mathematics and their level of confidence in mathematical PCK. The extent to which this knowledge was gained within the school setting will be considered.

Within Section 2.3 I defined my view of the key components of mathematical pedagogical content knowledge. Within this two aspects can be seen to relate to the development of an understanding of pupil progression. This is:

- An understanding of the ways in which children learn mathematics, and the teaching strategies and resources teachers can utilise within this process;
- An awareness of pupil progression within the mathematical topic area to be taught, including the fundamental building blocks which support pupils' progression to the next level of attainment.

Data analysis revealed that this understanding was linked strongly to confidence levels in mathematical PCK, with trainees feeling that they were successful within the classroom when they were able to effectively meet the needs of all of their pupils. A fundamental part of this knowledge was the specificity of knowing the pupils within the class – what their prior

learning had been and what their next steps are likely to be. When asked to consider the aspects they drew upon when planning a mathematics lesson, EBITT trainee 6 outlined that,

'It is establishing, when have we last covered that and what have we done before? How have we tackled that before? How good were they at it? Not going back over the same ground but trying to tackle it in a slightly different way and move them on a little bit.' (EBITT trainee 6)

Alongside this however was the wider knowledge of progression within the specific mathematical topic area being addressed and the inter-relationships between the different aspects of mathematics: number, shape and space and data handling. This included a consideration of the essential steps needed to advance learning and ideas about teaching approaches and resources that could be utilised to support this progression.

'It is seeing the building blocks and the baby steps that they take...They are learning about shape and they suddenly have to go onto counting and they have to count the number of sides' (EBITT trainee 7)

Alongside this the importance of developing a strong awareness of how to support pupils to overcome the errors and misconceptions they encounter as part of their day-to-day teaching was highlighted. Trainees were seen to draw upon a range of sources, including theoretical academic research, in order to enable them to adapt their subsequent pedagogical approach and take forward pupils' learning,

'One of my lower ability Year 1 girls had a real problem with identifying teen numbers. I looked in Haylock and it said that it was a mixture of not knowing what they were as a quantity or why they are written like that. Eighteen 'says' eight first – children know it needs a

1 so they often write 81. [As a result] we are continuing to work on place value and making the numbers practically with unifix.' (EBITT trainee 8)

Centre-based training could be seen as important in supporting this aspect and will be considered in detail within Chapter 5. However within the school setting observation of good practice and discussions with experienced teachers was seen as being vital in supporting the development of this aspect of mathematical PCK. These activities allowed trainees to gain information about the learning needs of the pupils they were to teach and the levels they were working at. This information was seen as being important as it enabled lessons to be differentiated,

'The better maths lessons I did were where the resources and the language I used were really secure and pitched appropriately for the year one class and the different abilities. I was so secure in it that I could easily differentiate.' (PGCE trainee 2)

It could be argued that EBITT trainees are better placed to develop understanding, confidence and success in this aspect of PCK, as they are placed within one class for the majority of the training year, and this leads them to develop an in-depth understanding of their pupils' needs and also see the progression of learning for a range of abilities over the course of a whole academic year,

'That is one of the benefits of being with a class over a long period of time. You are watching them grow and develop over the year. Whereas I have seen other students who come in and out on 4-week blocks and they don't have long enough to get to know the children...you only get a snapshot. You need time to weigh up their strengths and weaknesses.' (EBITT trainee 6)

For PgCE trainees their involvement with one class was fragmented with only six weeks at a time spent within a particular school. The PgCE trainees saw this aspect as a challenge but it was interesting to note that none of the trainees interviewed felt that it was a factor that stunted their development.

'It is about knowing your children and that is something major. It takes you a while obviously but when you know the ones who are going to struggle and you know that they are going to need your support, then you have to think about how to tailor things to them...I ended up making visual aid cards which related to mode and if they were not sure they could turn it over and were told how to do it' (PgCE trainee 4)

There was evidence that they were adept at drawing upon guidance from the class teachers, but also a realisation that full understanding of pupil progression may not be gained until they have developed into an experienced teacher, post-qualification. PgCE trainees are able to draw more readily on knowledge gained from centre-based training as they complete fifteen mathematics sessions across the training year, compared to six for EBITT trainees – this will be examined further in Chapter 5.

Alongside this was the development of a secure knowledge of the possible misconceptions and difficulties that children may encounter within a particular area of mathematics, and ways in which these can be addressed. Again this was an aspect where trainees drew upon the advice of experienced teachers and information gained at lectures.

There was evidence that trainees felt that the gaining of knowledge about progression and the ability to find solutions was an important aspect, which made the difference between being a teaching assistant and an effective teacher. When asked whether they are stronger at teaching mathematics now as a trainee, EBITT trainee 7 reflected that,

'I remember when I was a teaching assistant, they would be doing an activity and I would think, "They don't get it. Why don't they get it? I must be doing the activity wrong." Whereas it is really their background knowledge and something they don't understand and they needed to know before what they are doing. That's how I have improved: knowing where they are, making sure that when I am teaching something they know the bit before.' (EBITT trainee 7)

A sense of achievement was felt by the trainees when they were able to see the progress that the children made – initially within one lesson, but eventually a series of lessons across time,

'[It's having] those effective lessons where you know that you walk away and you have made a difference. Not that you have taught and the children have revisited but that you have gone in and you know that you have moved the learning on.' (EBITT trainee 4)

There was also evidence that mentors viewed this ability and knowledge as evidence of a competent teacher,

'I look at the learning and the progress that is going on [when observing a mathematics lesson]. Not just in terms of what the teacher is doing but in terms of how the child is not just telling you what they are doing but they are explaining why they are doing it and the thought processes behind it. It is looking to see if they have thought about any barriers that might be there in learning and what they might have done to address this. It's meeting the needs of all learners and making sure that they have all made progress.' (Mentor 1)

4.4 The second school experience

The Initial Teacher Training Criteria (NCTL, 2014) sets out the expectation that all trainees will teach in at least two schools during the training year. For the EBITT trainees, this four-

week experience in the spring term was seen as valuable (Griffiths, 2007; Smith & Hodson, 2010), and had an important impact on confidence levels in the teaching of mathematics,

'It is great that we have the two schools and we are able to draw upon the different experiences because I felt at the second school that was where I became a teacher. It was extremely good to be able to see outstanding mathematics teaching daily for a period of time. When I had to teach them I had to make sure I gave them the equivalent challenge. When I came back to my base school, I tried to apply that.' (EBITT trainee 3)

As outlined in Section 4.1.3, EBITT trainees within this provider often train within a school in which they have previously worked, either as a teaching assistant, nursery nurse or in some cases as an unqualified teacher. This can be seen to bring about both advantages and disadvantages. The trainee is likely to already be familiar with a large number of the policies and practices within the school, and they will already have been inducted into the community of practice (Mutton et al, 2010, Wenger, 1998) that exists, albeit in a different role to that of a trainee teacher. For some trainees this aspect proved to be a challenge as they were faced with pre-conceptions about their ability as a teacher, and if they did not meet these expectations they were faced with feelings of failure. For others their experience was positive but it could be argued that they were working within their comfort zone, and they were yet to prove that they were able to function as a teacher of mathematics outside the specificity of this setting. For the PgCE trainees the transference to a new school setting was not seen as having a notable impact. This was likely to be due to the fact that they do not embed themselves within one community of practice, as only a short period of time (six weeks) was spent in each school.

For some trainees this second school experience enabled them to develop a fuller understanding of pupil progression in mathematics, as it involved working within a different age group, where they were challenged to plan and teach children from a range of abilities

that they were not familiar with. This provided them with the opportunity to consider the steps of learning in mathematics, and they were able to draw links with the children they usually work with and see more clearly the progression within mathematics.

Their mathematical pedagogical knowledge was enhanced through the necessity to differentiate for the range of abilities within the class and this was particularly challenging if the trainee had spent most of their previous career in school, within one particular age group,

'I found that the second school placement was a huge learning experience for me. I was out of my comfort zone as I had been in early years for many years. I found myself in year 2 and in a school that used setting for mathematics. It was the bottom set but within it there was huge range of abilities.' (EBITT trainee 1)

The specificity of a particular school context revealed some variation across trainees, with a second school experience having the potential to reveal differences and/or similarities in terms of the teaching approaches and ethos across schools (Smith & Hodson, 2010). One trainee stated that the experience demonstrated that settings are different and that,

'What works with one class does not always work with another, or what works with one student doesn't work with another.' (EBITT trainee 2)

This could be said to prepare the trainee for their future teaching career as it encouraged them to broaden their horizons and be prepared to adapt and extend their repertoire of mathematical PCK knowledge.

'I think it is acknowledging the exposure that children get in different school settings. I think it is really good to see those two settings and understand the expectations of the two schools and the children in there.' (EBITT trainee 2)

At the same time another trainee was boosted by the realisation that some basic mathematical pedagogical approaches are able to successfully be transferred across schools and age ranges,

'I did receive positive feedback...the observer said to me that the key issue is that I am taking an approach from early years – concrete resources and really engaging materials – and it made all the difference. I was proud of myself for this.' (EBITT trainee 1)

For trainees the second school experience also provided an opportunity to address deficits in the support structure (Griffiths, 2007) or the teaching of mathematics within their base school. This included the opportunity to have in-depth discussions and engage in mathematics planning alongside experienced teachers,

'In my second school that's where I felt that I became a really good maths teacher because we had discussions, we had plans. We picked up on things immediately after the lesson.' (EBITT trainee 3)

One trainee also highlighted how the whole team approach to the teaching of mathematics enhanced both her ability to plan and also her understanding of mathematical progression and the range of pedagogical approaches. This new knowledge developed her confidence and that was then transferred when she returned to her base school,

'Planning was entirely different – we sat down as a team and you planned and you could bounce ideas off of each other. It was so effective in moving my learning on in planning, so

when I went back to my base school with all of this, I said, "You know what, I can do this?"
(EBITT trainee 3)

For other trainees the most important aspect was moving into a new community of practice - one in which they were not known (Smith & Hodson, 2010). This meant that they had the opportunity to prove themselves as teachers of mathematics and this led to a great feeling of success when this happened,

'They didn't know me. There was nothing I was fresh. So what I showed them was who I am. There were no preconceived ideas and that was a massive learning curve. So I knew whatever they gave me and whatever I was graded as there, that would move me on because they had seen me fresh. They didn't have any report on me because I arranged my own.' (EBITT trainee 3)

4.5 Summary

This chapter has examined the role of the school setting in developing trainee teachers' mathematical PCK. Within the community of practice the trainee was supported through a structure provided by a range of school practitioners, including the mathematics subject leader. The opportunity to observe a range of good practice in mathematics was seen as being important in extending the trainees' repertoire of teaching strategies and developing their vision of good mathematics teaching. However it could be argued that unless opportunities are provided to discuss the practice following the observation then in-depth understanding of the teacher's pedagogical choices will not be achieved.

Trainees also valued the feedback they received following observations of their mathematics teaching. This provided them with an opportunity to reflect upon their practice, a chance to identify strengths and areas for development and also an opportunity, through discussion, for the extension of their pedagogical approaches. However it could be questioned whether

these discussions focused on the pedagogical aspects of mathematics or whether they tended to address more generic matters of class management and general pedagogy.

The class teacher was viewed as playing an important role in supporting the trainee in an ongoing manner and this was valued as they were able to provide a strong focus on the specific mathematical needs of a particular class of pupils. This opportunity to work together to promote learning meant that both the trainee and class teacher were likely to invest a lot into the partnership. However this could lead the trainee to feel constrained in their approach to teaching and become afraid to move away from the norm established by the class teacher. For the trainee's development to continue it was important that the class teacher allowed the trainee the freedom to innovate, so that they were able to experiment with and generate their own mathematical pedagogy.

The role of the mathematics subject leader in providing specialist support, including the modelling of good pedagogical practice, was highlighted by a number of trainees. This support was seen as particularly valuable when planning for teaching and considering the range of possible pupil misconceptions. The best learning community could be viewed as one in which the school offers a supportive and open environment, in which the expertise of a range of practitioners can be drawn upon.

At the same time, the opportunity to move away from the specificity of the mathematics teaching in one school and the community of practice through a second school experience was seen as being valuable. Through this trainees were able to develop a greater understanding of pupil progression in mathematics, expand their repertoire of pedagogical approaches and confidence was enhanced through the success they experienced.

Chapter 5 – The Centre-based Setting

This chapter draws upon data gathered from trainee and mentor interviews and questionnaires to consider the ways in which the mathematics centre-based training element of the course offered by this primary ITT provider, supported the development of trainee teachers' mathematical PCK. The perspective of the mathematics course tutor will also be drawn upon.

Firstly, the specific structure of the mathematics centre-based training for this provider is considered, including the key aspects of mathematics covered over the course of the year and also the teaching strategies deployed. The content of a particular observed mathematics training session, which focused on progression in pupils' learning across the primary age range within the area of algebra, will be considered, in order to analyse the degree to which particular aspects of mathematical PCK are addressed. Following this, the trainees' perceptions of the ways in which the sessions support the development of mathematical PCK is considered, including:

- i. developing knowledge of teaching and learning strategies in mathematics,
- ii. exploration of mathematical resources,
- iii. supporting observations of good mathematical practice,
- iv. understanding of pupil progression in mathematics and
- v. opportunities to move away from the specificity of their school's practice and share experiences with others.

Throughout this chapter, the ways in which mathematics centre-based training supported and developed experiences within the school setting is highlighted, including the enhancement of reflective practice.

As reported in Chapter 4 in relation to school-based training, I also found that when gathering and analysing data in relation to the impact that mathematics centre-based training had on trainees' confidence in mathematical PCK, it was important that I ensured that the responses gained focused specifically on mathematics training that the trainees had received rather than more generalised comments about the overall impact of all centre-based training undertaken within the training year. In order to maximise this I ensured that my questions, both written and oral, made specific reference to mathematics. If I felt the respondents were talking more generally during the face-to-face interviews I asked for clarification of the mathematics aspects or reminded them of the mathematical PCK focus of this study. Overall on reflection, I believe that when talking about centre-based training trainees were more readily able to stay focused on the mathematics aspects. This was due to the fact that lectures focus on a discrete subject area, in this instance mathematics, unlike a mentor/trainee school-based discussion for example, which may cover, within one overall conversation, both generic primary teaching and mathematics subject specific aspects.

5.1 Overview of the structure of centre-based training in mathematics

Centre-based training within this ITT provider was defined as training that took place away from the trainees' placement school setting. This occurred in classrooms based at the provider's lead school; led by current primary practitioners who are experts in their particular subject area. As well as her ITT role, the mathematics tutor worked as a consultant within a range of local schools. This provided her with an in-depth understanding of current practice in mathematics within local primary schools; this knowledge supported her role with the trainee teachers. Table 5 (overleaf) outlines the time allocated by this provider to particular aspects of the ITT training year.

Training route	Time allocated to aspects of the course		
	School based practice	Centre-based training 1 day = 2 x 3-hour lecture	Mathematics specific centre-based training 1 day = 2 x 3-hour lecture
EBITT	172 days	25 days	6 x 3-hour lecture
PgCE	120 days	75 days	15 x 3-hour lecture

Table 5: Time allocated to particular aspects of the ITT training year

The extent to which the amount of time spent in centre-based training potentially impacted on the development of trainee mathematical PCK will be discussed in Chapter 6.

It should be noted that individual ITT providers decide on the amount of time that they allocate to centre-based training in mathematics and also the format and structure of these sessions, so this needs to be taken into consideration when generalising the findings of this study for teacher training as a whole.

Observation of a mathematics training session provided an overview of the structure and types of activities that took place. The tutor was unaware of my intention to observe the session until just prior to the start of the session so it was likely that the format was not changed greatly in light of my presence, although I cannot discount entirely the possibility that some elements were adapted. The tutor confirmed however that this session was typical of the format she usually follows. The ways in which the data was recorded during this session and subsequently analysed has been outlined in Section 3.4.3.

Throughout the session there was strong trainee participation, and very little of the time was didactic (7% of the time). The session developed the trainees’ knowledge and understanding of pedagogical approaches in the teaching of algebra, through the exploration of ideas using a combination of paired, group and whole class discussions (66% of the time) and paired/group practical work (25% of the time). (See Appendix H for an overview of the

mathematical activities undertaken). This structure allowed the trainees to share ideas, ask questions and explore mathematical concepts, strategies and resources throughout. The specific ways in which mathematical PCK was developed in this session will be outlined in the remainder of this chapter, beginning with the ways in which teaching and learning strategies in mathematics were addressed.

5.2 Developing knowledge of teaching and learning strategies

Pedagogical content knowledge is the ability of the teacher to transform the content that they process into a pedagogical form that has been adapted to suit the needs and abilities of the children they are teaching (Shulman, 1986). With this in mind, the aspect of centre-based training that focused on the development of trainees' knowledge of teaching and learning strategies was of utmost importance. Research (Hobson et al, 2009; Russell, 1988; Smith & McLay, 2007) indicates that trainees value highly this aspect when it is regarded as tips and ideas for teaching - believing that these ideas will enable them to function successfully back in the classroom. However this aspect of training is devalued if it is viewed purely as tips, and must be approached alongside a desire to understand why particular strategies are effective (Alexander, 2009; Russell, 1988) and how they relate to pupils' stages of learning. This ensures that implementation is undertaken with meaning.

An analysis of questionnaire data in relation to the question, "In what ways has centre-based training developed your knowledge and confidence in the teaching of mathematics?", revealed that the trainees valued the focus on the exploration of the mathematics curriculum and the related teaching strategies,

'You need to have the lecture grounding. I wouldn't have known that there were so many [mathematical] strategies. It developed my understanding of the current calculation strategy used by primary children.' (PgCE trainee 4)

Trainees were aware that current recognised mathematics calculation strategies might differ from what they were taught at school, so they wished to, *'bridge the gap between methods used in my own education and modern methods'* (EBITT trainee 1). The mathematics tutor expressed her belief that the realisation that things are different can often lead to a lack of confidence, as trainees can feel overwhelmed by what they perceive they have to learn. At the same time she recognised that sometimes trainees come into the subject with misconceptions as a result of beliefs that existed when they were educated. This aspect needed to be tackled with sensitivity as,

'Often if you think you know something and it is challenged or not quite right it makes you think, "What else do I not know? What else is wrong?" You begin to lose your confidence'
(Mathematics tutor)

It is important that trainees are exposed to new visions of how mathematics should be taught (Borko & Mayfield, 1995; Feiman-Nemser, 2003). As explored in Section 2.4.2, trainees can feel anxiety and lack positivity about the teaching of mathematics as a result of negative experiences during their own schooling (Borko & Mayfield, 1995; Britzman, 2003; Mutton et al, 2010). Alongside observations of good practice in school, centre-based training helped trainees dispel these fears and develop alternative approaches that exemplified good mathematics teaching and developed their confidence,

'Working from exercises with very little teacher support resulted in me never developing an understanding of number at school. Teaching strategies shown and opportunities to practise and discuss has helped me to acquire knowledge and confidence as an adult.' (EBITT trainee 4)

The mathematics tutor recognised that low confidence levels were often an issue and therefore one of her primary aims was to tackle this aspect,

'I aim to encourage confidence in people when they are teaching maths. They see it as quite formal and paper-based. I try to get away from that and encourage them to be playful and practical. I want them to feel more positive and have a go.'

Trainees sought out an approach to teaching which differed from the *'textbook question led and boring'* (PgCE trainee 8) methods that they experienced as a child, and so appreciated the focus on practical activities. Alongside this was an appreciation of why this approach was necessary,

'It gives you some grounding so that you are not going in blind, but with some grounding of this is the way I should be putting things across. Children need the practical side before you move on.' (PgCE trainee 4)

To enable them to achieve this trainees needed to gain pedagogical knowledge about the steps for learning within particular aspects of mathematics, and relevant to the age phases they were working within. Information gained from interviews and questionnaires revealed that trainees understood that for teaching strategies to be effective they must have an effect on pupils' mathematical learning. PgCE trainee 4 described how centre-based training assisted them in teaching the Four Operations,

'I want[ed] to gain the best tools possible and the best way to break things down so that you have your end goal of the children learning. It helps you know how to structure the lesson.' (PgCE trainee 4)

The observation and subsequent analysis of the centre-based mathematics session revealed that this was a strong feature of the session. 65% of the session focused on the exploration of mathematics teaching strategies. As highlighted earlier the mathematics tutor

sought to engage the trainees and facilitate learning through an interactive approach, therefore strategies were explored through a combination of practical activities and discussions. This resided in the belief that understanding is enabled through the provision of opportunities for the trainees to experience the strategy for themselves,.

'If you pitch it at the theory, this is what you should do, then they go away and get annoyed that maths is just abstract. This is just reinforcing the view they had when they were at school. Maths should be something you discover for yourself through doing it yourself.'
(Mathematics tutor)

Furthermore, discussions during and following the practical activity, supported the trainee in understanding the process they had undertaken both from their own and other's perspectives. The tutor was able to support on an individual or group basis as required, and timely interventions enabled the trainees to see the relationship between the skill and pupils' understanding (Edwards & Collison, 1996). Appendix H provides an overview of a section of the session, highlighting the content and how this linked to mathematical PCK. Data from interviews indicated that by experiencing these strategies for themselves trainees are more likely to appreciate the benefits of the strategy and therefore it is more probable that they will incorporate this into their own classroom practice,

'Being given the opportunity to try tasks that would be asked of children and discuss different elements of these has informed classroom practice.' (EBITT trainee 4)

Additionally an important aspect of enabling pupil progress was seen as the development of an awareness of common pupil misconceptions within mathematics and how these may be overcome. Centre-based training was seen as providing this insight,

'I think that it's understanding the building blocks and progression for children. Being able to see what knowledge they lack or what they may have misunderstood so that you can help them move on. For this reason (one of the mathematics lectures) I spent two weeks on ordering numbers and knowing one more and one less because I knew the children wouldn't be able to move onto adding/subtracting without knowing where the numbers 'are.'" (EBITT trainee 18)

Mentors also recognised the value of mathematics centre-based training in exposing trainees to a range of pedagogical approaches, much broader than what can be provided within the school setting,

'The subject knowledge they learn in-house is important too and the ideas of different ways to teach maths. It is sometimes difficult to think of different ways, exciting ways. You do cover quite a few different ways.' (Mentor 2)

Goulding et al (2002) suggest that there are strong links between trainees' PCK and their subject matter knowledge (SMK). This refers to the amount of knowledge per se the teacher possesses in relation to the topic area being taught (Shulman, 1986). It is suggested (Goulding et al, 2002) that a good mathematics teacher is able to utilise strong SMK and PCK to plan effectively for sequences of lessons and to respond to the pupils' needs within the lesson in-action. This was acknowledged in the trainee interviews with PgCE trainee 4 stating that,

'It's definitely a confidence thing but it is knowing your maths material. Subject knowledge per se is interlinked. If you haven't got that confidence in your own ability you are going to want to stick to your plan regardless. You need to have the knowledge, what we have been taught in lectures so that if it is not working, this is what you can try.'

Within the observed mathematics lesson SMK was addressed for 49% of the time. However this was seldom addressed as a standalone aspect, but was effectively integrated into the exploration of teaching strategies. The mathematics tutor highlighted how she aimed for trainees to learn some mathematics for themselves as part of her sessions. This centred around her belief that, *'the more you know yourself the more confident you are teaching it.'*

Data gathered from interviews indicated that by engaging with these tasks in this integrated and practical way the trainees were also constantly refreshing and developing their SMK,

'Lots of things I had learnt over 20 years ago in my case and I had completely forgotten. We went back to the early stuff. That's what we call x, y and z. It crystalised a lot of things for me and was really helpful.' (EBITT trainee 6)

Additionally there was evidence that the trainees engaged in analysis and reflective practice as part of the centre-based training sessions, allowing them to develop knowledge about (Edwards & Collison, 1996) the teaching of mathematics rather than just how to teach.

'For me it made me look at the theory – cardinal and ordinal numbers. You understand why. They [the children] need to be able to do that bit.' (EBITT trainee 6)

This analysis led to the consideration of possible misconceptions, with trainees in their school setting being able to draw upon centre-based training aspects in order to understand why children experience particular difficulties,

'I taught time which was a tricky one and you start to analyse things. You say "Wait a minute" but it is not actually a minute. The children can get real misconceptions about time and distance. It's the lectures and thinking about it – analysing this.' (PgCE trainee 5)

Part of this reflective process was the need for trainees to make decisions about the effective selection of strategies for use within their own classroom setting (Malderez & Bodoczky, 1999). In their school trainees tested out the strategies provided within the centre-based setting and in doing so gave meaning to what they have learnt (Edwards & Collison, 1996; Russell, 1988). Reflecting upon how she had successfully adapted an Early Years idea from centre-based training focused around counting rhymes and songs to teach mean, median and range to a struggling year 5 mathematics set, PgCE trainee 4 stated that,

'What is great is that we are shown ideas of how you can put things into practice and the great thing about the PgCE is that it is the best time to try them out and develop your own pedagogy. You think 'I tried this but it didn't work for me so I won't use it again.' (PgCE trainee 4)

The opportunity to move outside of the school setting was seen as a positive aspect of centre-based training. Trainees recognised that the school environment is fast-paced and pressurised and may not always allow them time to stand-back, explore, reflect and ask questions. They therefore valued the opportunity to work with their peers and the mathematics tutor - who they saw as an expert.

'In school you don't have the time to develop you are just expected, and you are with the children so you have to make the best of it. Here [the centre] you can ask questions in a non-time pressured environment...it feels like here is where you can ask all the questions and iron everything out.' (EBITT trainee 5)

The mathematics tutor's approachability was seen as a boost to trainees' knowledge, understanding and mathematical PCK confidence levels.

5.3 Exploration of resources

Trainees in both the questionnaire and interview element of the study highlighted the sharing of resources for mathematics as a key aspect of their learning within centre-based training. The session observation revealed that the use of resources was embedded throughout the fast-paced practical activities, in which trainees explored with their peers a wide range of strategies and resources they could use within the classroom, so developing their mathematical PCK. Many resources were everyday mathematical items, such as counting cubes, number cards, number squares and matchsticks, or interactive and printable resources available freely via the Internet (See Appendix H). This could be considered to be particularly valuable to the trainees as they were not being shown expensive resources that they may not be able to obtain in their schools and so not be able to put into practice.

This exploration of resources could be criticised as merely providing trainees with another strand of ideas for use within the classroom. However there was strong evidence that the exploratory approach the trainees engaged in with their peers, led to both analysis of the resource's use,

'If you have explored the resources fully yourself you can think we are not just going to put them down on the table and count them. We are going to pull them off one by one and count them, so we are literally taking them away.' (EBITT trainee 1)

Also the collation of a range of ideas and experiences creates an expanding repertoire in relation to mathematical PCK,

'If you are on a table together and working together you can see the different approaches and think outside the box because we tend to think about one particular resource. In my

school everything is about Numicon but sometimes you need to be counting knitted sweets first.' (EBITT trainee 1)

In this instance it could be questioned whether the trainee would have the freedom to innovate and try a new approach if the school is entrenched in one particular approach (Feiman-Nemser, 2003). The mathematics tutor however expressed her view that this did not seem to be an issue with *'schools being forward thinking and trainees being allowed to try things out.'* It was noted that trainees stated that they were able to *'experiment with various resources which I then used on my placement'* (PgCE trainee 7), and that in one instance there was evidence of resource ideas being shared with whole school staff and impacting upon wider practice.

There was evidence that trainees were reflective and experimental in the use of resources within the school setting. Research (Russell, 1988) suggests that trainees often think that good ideas from centre-based training will transfer un-problematically into the school setting, but this is not always the case. It is important that trainees develop an awareness that ideas and resources need to be chosen and adapted to suit the particular needs of the children they are intended for. Centre-based training only provided the knowledge and ideas, and these needed to be personalised for the children, the school and the trainee,

'We have been given an awareness of the different tools you can use and that gives you the grounding and you can pull from that...and put into practice. If they don't work then that might just be for that particular group of children.' (PgCE trainee 4)

PgCE trainee 2 highlighted that although it was valuable to work with resources within centre-based training, full understanding did not come until children were seen using them within the classroom.

This notion of understanding the use of resources in mathematics rather than merely using them was highlighted by the trainees, with a belief that this understanding demonstrated the transition from being a teaching assistant to a teacher,

'I remember thinking as a teaching assistant that is a lovely bead string but what do I do with it? I had no idea and I would be thrust things and I wouldn't know what to do with them. So she [the tutor] has taught me how to use the resource properly.' (EBITT trainee 5)

This acquisition of knowledge and understanding was however seen as a gradual process, with trainees wishing that they had access to all of the resources and strategies early in the course, so that they could draw upon them whilst reflecting in action,

'You need to know the resources. If I had more experience I could have seen in the first lesson that they were not getting it and I could have got some resources and gone straight into it. I had to finish that lesson and then think about it and do it.' (PgCE trainee 5)

The challenge for the mathematics tutor was to make a decision about the order in which topics were approached, and also in the case of the EBITT route, what to include and what to leave out. She outlined how the content was adapted so that trainees had the key points, and that although discussion and practical activities took place, less time was allowed for them. The EBITT trainees were also expected to be more proactive in following up and developing knowledge gained at sessions through background reading and tasks in school. These were signposted by the tutor and discussed within subsequent sessions on a termly basis.

5.4 Supporting observations of good practice

Trainees highlighted how information gained from centre-based training was utilised when undertaking observations of good practice in mathematics teaching. Their experiences at

the centre provided an insight into the reasoning behind teachers' actions within the classroom,

'I had observed teachers [prior to the course] but I didn't really know what went behind it – why they are doing it...I didn't know at the time that it was the right thing to do to use the proper language in maths. It is only since doing this course that during the lessons I keep thinking back, "Oh that is why they do that all the time. That's why they are modelling all the time." (PgCE trainee 5)

Within Section 4.1.6 the value of discussions with the teacher following observations of good practice (Pinder, 2008; Zanting et al, 2003) was highlighted. The degree to which this was implemented was seen to be variable, indicating that the ability to draw upon information from centre-based training to develop understanding of the reasoning behind teaching actions would be a suitable substitute if the observed teacher was unable to take part in discussions. The ideal however would be a discussion that draws upon what was seen and information gained from centre-based training, so that the practical aspects seen within the classroom can be interlinked to the theory of how children learn and how teachers enable this, so leading to greater depth of understanding.

Additionally, the value of centre-based training in providing a focus for observations including key aspects of mathematical teaching and learning, and the subsequent impact that this had upon their own teaching, was highlighted.

'I think [mathematics] lectures give you awareness more than anything. It just gives you an awareness of what you are looking out for and things to notice. I think it is the awareness we have from the lectures that is always in your mind. Then when you go into your own teaching you are very aware of key vocabulary that you want to put across and the best tools you can give children to get over common misconceptions.' (PgCE trainee 4)

The observation of a mathematics centre-based training session demonstrated that the tutor used an experiential approach to training; this instilled knowledge into the trainees' minds more readily than if they had just been told it.

Mentor 1 outlined the way, in which the pedagogical skills base was developed as a result of centre-based training and through reflective practice,

'Probably from here [the centre]. The reflection, the research skills to go and look at things, thinking about things and wanting to be a learner again. It is the skills that they come with and they can then act on them.'

Trainees are often keen to see in practice what they had learnt within centre-based training but trainees do not always cross-reference and reflect explicitly on the links (Tang, 2003). The best practice would include opportunities within the school setting for the trainee and mentor to discuss and make these connections together through reflections. However mentors suggested that they are not always fully aware of what has happened within centre-based training, and this is an area that could be developed by the provider.

5.5 Understanding of pupil progression

As highlighted in Sections 5.2 and 5.3, centre-based training provided trainees with knowledge about potential teaching strategies and resources that could be utilised within the classroom. At the same time training provided an overview of curriculum expectations and *'developed understanding of different strands of mathematics which aided planning'* (PgCE trainee 7). An important aspect of this was the understanding of pupil progression within a mathematical topic area, with this knowledge supporting differentiation. Within the session observation there was clear evidence of pupil progression being addressed (15% of the allocated time). Over the course of three hours the topic of algebra was explored starting

from the early years foundation stage curriculum and concluding with an examination of how to challenge the more able learners within year six. This focus on the whole primary age range allowed the trainees to move away from the specificity of the age they were working within and gain a broader perspective that may aid any transition to another age range in the future. PgCE Trainee 4 described how being exposed to early years teaching strategies allowed her to consider how ideas can be adapted to suit the needs of different age groups,

'I wouldn't have thought of taking an early year's tool and adapting it for my needs. It would not have entered my head to think let's put it into a song or nursery rhyme. I think that if I had just been in school, unless I had seen it, it wouldn't have entered my mind. We don't just focus on KS1 or KS2 because we do the whole spectrum. Whereas if you were in school you would be in your one key stage and your one year group and you would be much more limited.'

This overview of pupils' progression across the whole primary age range also supported the trainees' transference to a different age group for their second school experience. Centre-based training was drawn upon when planning age appropriate lessons as trainees had already acquired some awareness of effective teaching resources and approaches to learning. Alongside this, the sharing of ideas with their peers was valuable (Smith & McLay, 2007) and was seen as an opportunity to develop pedagogical knowledge and understanding away from the specificity of the class and/or school setting.

5.6 Summary

This chapter has examined mathematics centre-based training and the ways in which it developed trainees' knowledge and understanding of a range of pedagogical approaches across the breadth of the mathematics curriculum. This training provided the trainee with the opportunity to move away from the specificity of the age range in which they worked, so enabling them to develop a view of progression in mathematics across the primary school.

Trainees were also able to engage in reflective discussions with their peers and share good practice, so enhancing both their mathematical repertoire, alongside their depth and breadth of knowledge and understanding of pedagogical approaches in mathematics. At the same time there was evidence that trainees were selective, within the school setting, in the ways they utilised ideas and resources they gained. They were able to make choices that suited the needs of their children and also their own teaching style.

Mathematics centre-based training also supported understanding and reflective practice within the school setting. It provided a focus for observation of good practice in mathematics and also offered explanations for why things are so within the classroom.

Trainees recognised that it was important for aspects learnt within mathematics centre-based training to be tested within the classroom. The analysis of data in this study demonstrates that this link is stronger – a symbiotic relationship in which theory and practice was engaged with and built upon within both the school and centre-based setting. Through a process of reflection and selection, theoretical and practical elements of mathematics encountered within the centre were explored within the school setting via teaching and reflective experiences. The trainee was able to generate through this process, their own theory about how particular children learn mathematics and the success of pedagogical approaches - ideas that in turn were shared with their peers and tutors. This important inter-relationship between the theoretical aspects of training and practice within the classroom will now be discussed in detail in Chapter 6.

Chapter 6 – Theory and Practice: the inter-relationship

During the initial teacher training year, trainees are exposed to both theoretical and practical elements of teaching mathematics (See Chapters 4 and 5). This chapter discusses a range of definitions in regard to the nature of theory and practice; linking these to the trainees' perceptions of the ways in which key elements of the training year led to engagement with both aspects. The inter-relationship between theory and practice is discussed, with each aspect being seen to have a profound effect on the other – combining to enhance trainees' knowledge and understanding in mathematical PCK. This is a reciprocal relationship that leads to a high level of value added in terms of trainees' confidence levels. This will conclude with a reflection on the extent to which trainees draw upon both theory and practice, and whether there is an optimal balance.

6.1 How can theory be defined?

Theory is the acquisition of knowledge and understanding about the professional craft of teaching (Hagger & McIntyre, 2006; Smith & Hodson, 2010). An analysis of the trainees' definitions of theory and practice within the November questionnaire (See Appendix O) provided an insight into perceptions of the nature of the mathematical knowledge gained through the theoretical elements of the course.

Firstly for thirteen trainees, theory was seen as gaining procedural knowledge (Ryle, 2000): how to teach mathematics. This aspect aligned strongly with PCK as it included a consideration of particular teaching strategies and resources that could be utilised to support children's learning, alongside an awareness of the developmental stages in which children learn mathematical concepts, and subsequent considerations within planning and teaching.

Secondly, six trainees linked theory to propositional knowledge (Ryle, 2000). This subject matter of mathematics referred to the body of knowledge which exists that encompasses the key facts, concepts and principles that make the subject unique.

Seventy percent ($n = 19$) of trainees within this study indicated that they had encountered negative experiences of mathematics during their schooling and that this had a detrimental effect on their ability within the subject and also their confidence and self-belief. This aligned with research (Borko & Mayfield, 1995; Britzman, 2003; Edwards & Collison, 1996, Mutton et al, 2010) that highlighted how childhood experiences within mathematics, including feelings of failure and embarrassment can lead to anxiety in the subject. The procedural and propositional knowledge gained through the theoretical aspects of the course were important as they enabled trainees to enhance and refresh their subject matter knowledge, alongside exploring up-to-date ways in which mathematics can be taught within the primary school. In this way theory can be seen as helping to overcome previous poor learning experiences that trainees may have encountered, thus enhancing their confidence level. Even when working at a primary level, trainees need the opportunity to revisit key mathematical concepts from their own schooling; being encouraged to consider gaps in their own knowledge and misconceptions that they may hold.

Finally three trainees viewed theory as “knowledge of why”. This could be defined as why something is so, for example “Why children benefit from the use of concrete apparatus” or developing an understanding about why children experience particular difficulties or misconceptions within the subject area. This could be viewed as an extension of propositional knowledge, in which the trainee develops a deeper understanding of the reasoning behind both mathematical approaches and factors affecting children’s learning. This was important as it developed trainees’ understanding of the reasoning behind the pedagogical choices teachers made within the classroom. Research (Alexander, 2009) suggests that this understanding of pedagogic knowledge is often under-developed within

teachers. Contrary to this, evidence from this study (See Section 5.1) suggested that this area had a strong focus in mathematics centre-based training within this provider, with the trainees being provided with practical opportunities to engage with and reflect upon a range of teaching and learning strategies and resources, linking these to pupil progression. This knowledge and understanding was then implemented within mathematical teaching within the classroom setting (See Section 4.3). The analysis of questionnaire data gathered at the early stage of the training year however indicated that initially it was the 'how to teach mathematics' that trainees expected from theory more so than the 'why'.

These perceptions of the theoretical aspects of training can be seen to align with Hobson's (2003) model, with just over half of the trainees (60%, $n = 13$) at the start of the training year having a proceduralist apprentice view of theory - seeing it as an opportunity to gain information in relation to how to be successful within the classroom. At the beginning stage of the training year, there was very little evidence of the trainees ($n = 3$) being understanding-oriented learners (Hobson, 2003), with a desire to critically understand why things are effective, or not, within the classroom. Research (Britzman, 2003; Fuller & Brown, 1975) suggests that in the initial stages of training, trainees' primary focus is survival within the classroom. In order to do this they seek knowledge of tried and tested strategies of how to teach. This they can secure from 'theory' gained from centre-based training and engagement with books and on-line resources focusing on ideas about how to teach particular mathematical topics. A closer analysis of the questionnaires revealed that the three trainees who had placed emphasis on theory providing a deeper understanding of pedagogical approaches, were EBITT trainees who had previously worked with a higher level of teaching responsibility within the classroom, one as a nursery nurse and the others as unqualified teachers. This indicates that this experience had allowed them to advance into the latter stages of trainee development (Britzman, 2003; Fuller & Brown, 1975), in which they wish to develop and demonstrate their own pedagogic skills with understanding.

6.2 How can practice be defined?

Practice can be viewed as the elements of the training year that take place within the primary classroom setting (Hagger et al, 2008; Hobson, 2003; Smith & McLay, 2007). The trainees' definitions within the November questionnaire (See Appendix O) showed a widespread consensus (78%, n = 21) that practice was related to experience, namely the act of 'doing' and 'teaching'. At this early stage of the training year, there was strong evidence that the trainees were viewing the practice of teaching mathematics in what could be defined as simplistic and low level terms, namely children engaging in mathematical activities and using resources. In only three instances did trainees refer to higher order skills related to teaching and learning: '*applying pedagogical knowledge*' (PgCE Trainee 14), '*supporting a child in their learning*' (EBITT Trainee 16) and '*children will understand and learn and develop*' (EBITT Trainee 6). As highlighted earlier, this lack of correlation between the practice of teaching and the children's learning could be related to the trainee's stage of development (Fuller & Brown, 1975; Furlong and Maynard, 1995; Russell, 1988) with the trainee not yet seeing themselves as facilitators of learning.

6.3 Theoretical and practical elements of the initial teacher training year

In order to fully understand the role that theory and practice play in the development of mathematical PCK it was necessary to gain an overview of the trainees' perceptions of which elements of the training year relate to theory and practice. This allowed the inter-relationships between the two aspects to be explored.

Within the November questionnaire the trainees were asked to identify whether they perceived particular aspects of the mathematics content of the course to be related to theory, practice or both. This was followed up in July when trainees were asked to consider the impact of theory and practice on their development within mathematical PCK.

Table 6 shows the findings from November.

Aspect of the training year	Theory	Practice	Both
	Number of trainees (Sample size = 26)		
Centre-based training	5 EBITT = 1 PgCE = 4		21 EBITT = 14 PgCE = 7
Private research and reading	18 EBITT = 8 PgCE = 10		8 EBITT = 7 PgCE = 1
Observation of good practice in mathematics	1 EBITT = 1	9 EBITT = 5 PgCE = 4	16 EBITT = 10 PgCE = 6
Discussions with mentor	2 EBITT = 2 PgCE = 0	7 EBITT = 3 PgCE = 4	17 EBITT = 10 PgCE = 7
Discussion with class teacher and/or mathematics subject leader	2 EBITT = 1 PgCE = 1	7 EBITT = 3 PgCE = 4	17 EBITT = 11 PgCE = 6
Discussions with other trainees (1 non-response)	4 EBITT = 2 PgCE = 2	9 EBITT = 5 PgCE = 4	12 EBITT = 9 PgCE = 3
Feedback from observations of your teaching of mathematics (1 non-response)	2 EBITT = 2 PgCE = 0	7 EBITT = 4 PgCE = 3	16 EBITT = 9 PgCE = 7
Your own reflections on your teaching of mathematics (2 non-responses)	2 EBITT = 2 PgCE = 0	7 EBITT = 3 PgCE = 4	15 EBITT = 10 PgCE = 5
Practical experience of planning, teaching and assessing in mathematics (1 non-response)	1 EBITT = 1 PgCE = 0	7 EBITT = 5 PgCE = 2	17 EBITT = 9 PgCE = 8

Table 6: Trainees' perceptions of key aspects of the ITT training year and their links to theory and practice

This data illustrated that the majority of trainees perceived most aspects of the training year, related to the teaching of mathematics, to contain both theoretical and practical elements. One notable exception to this was private research and reading. All bar one of the PgCE trainees viewed this aspect as theoretical, due largely to the fact that they were required to engage with a range of academic texts as part of their assignments (A 3,000 word essay focusing on misconceptions in mathematics and a 10 minute presentation focusing on supporting more able learners in mathematics). For the EBITT trainees research and reading were split more evenly between purely theoretical purposes and both. Within the interview element of this study six of the EBITT trainees were able to explain their engagement with a range of texts, academic. When asked where the ideas came from that enabled them to teach an effective mathematics lesson, EBITT trainee 4 stated that,

'Looking at research, authors like Haylock are brilliant because he writes in a very clear way and simple style that you can understand.' (EBITT trainee 4)

Additionally when reflecting upon the search for a stimulating pedagogical approach for a mathematics lesson, EBITT trainee 6 stated that,

'There is so much information out there and ideas that other people have used. You hunt around and some things appeal to you and others don't and it's sifting things.' (EBITT trainee 6)

Reading also supported, in the case of two trainees, the development of pedagogical knowledge:

'In Haylock it is there...I went back to researching. I had to go back and think they didn't get this, how can I break it [mathematical concepts] down so that they actually see it.' (EBITT trainee 3)

This notable difference in the perceptions of research and reading between the PgCE and EBITT trainees may be linked to the differences in the amount of centre-based training undertaken by each cohort (18 hours for EBITT trainees compared to 45 hours for PgCE). For EBITT trainees the deficit in sessions led them to seek out other sources that provided ideas and theory related to mathematical pedagogy, including written texts. This was an aspect that was acknowledged by the mathematics tutor who indicated that for the EBITT trainees there were limited opportunities to discuss and experience ideas, concepts and resources in-depth within training sessions. Instead her role was to introduce and signpost key aspects - with trainees being encouraged to explore further through reading and discussions with school-based colleagues. Data from trainee interviews indicated that this encouragement of follow-up reading and discussions was good practice, as it provided an

extension and a bridge between the experiences within lectures, which are theoretical, in that they operate away from children, and the practical experiences alongside children in the classroom. With this in mind it was necessary to consider the extent to which these practical experiences in schools draw upon perceived theoretical aspects.

It was noted that a relatively small number of trainees ($n = 7$) viewed school-based activities as purely practical. Closer analysis of the overall responses in relation to the perceived practical and theoretical elements of the course from these seven trainees revealed that for four trainees other aspects of school-based training were also perceived as being purely practical. This included observations of good practice, discussions with colleagues and their own reflections on lessons. In these instances it could be suggested that the experiences that were taking place in the school setting, including discussions with experienced teachers, were not enabling or encouraging the trainee to make in-depth links to theory, including the analysis of why things are so and how they are effective. Or such discussions were taking place but the trainee was not recognising them as theoretical. Further research in which mentoring conversations are observed would enable this aspect to be explored in greater depth.

For eleven trainees within this study mathematical discussions that took place with the mentor, the class teacher and/or mathematics subject leader were perceived as focusing on both theory and practice. Research (Borko & Mayfield, 1995) suggests that in most instances these school-based conversations rarely focus on an in-depth exploration of children's learning. The analysis of the role of the class teacher in Section 4.1.7 however indicated that this was not the case in this study, with trainees highlighting the key role that the class teacher played in providing information about the mathematical learning needs of the children within the class and support with planning, in which appropriate choices about pedagogical approaches were made. Mathematics centre-based training provided trainees with a broad overview of possible expectations in relation to children's age related learning

needs. Discussions with the class teacher however provided an enhanced and specific view of the mathematical needs of a particular class and the individuals within it. Trainees combined both aspects – the overview and the specifics – converting the theory of what was possible into the reality of the practice of planning, teaching and assessing within the classroom. In the initial stages trainees relied heavily on the class teacher's input and knowledge, but greater independence was sought as the trainee, through their own practice, developed a greater understanding of the children's needs and a repertoire of effective pedagogical strategies. Further evidence in Section 4.1.8 additionally highlighted that the mathematics subject leader is key in providing theoretical background related to both common misconceptions within mathematical topic areas and also pedagogical approaches that are appropriate to the developmental learning needs of the children. This indicated that these discussions focus on both procedural and propositional knowledge as defined in Section 6.1 – the how and the why of mathematical PCK.

The analysis of feedback from formal lesson observations in mathematics (See Section 4.1.5) indicated that the theoretical aspects of discussions focused largely on the procedural aspects of theory rather than propositional knowledge. Through the effective use of questioning by the observer, the trainees were able to engage in reflective dialogue that enabled them to consider the 'how' aspects of knowledge through the development of banks of ideas and strategies. In best practice there were also opportunities to reflect upon why particular pedagogical approaches in mathematics lessons were effective, or not, alongside how future practice could be developed.

Discussions within the school setting, both formal and informal, provided an opportunity for trainees to make links between theoretical and practical elements of mathematics teaching. The majority of trainees ($n = 17$) indicated that this was their experience. However the scope of this study was limited and further research would be necessary in order to ascertain to what extent 'why' aspects of knowledge are explored within the school setting, or whether

conversations focus primarily on the 'how to teach', with centre-based training providing the background understanding of why particular pedagogical approaches in mathematics are effective. The propositional aspect of theory was gained through elements of centre-based training, but as this could not provide the full scope of the primary curriculum within the time allocated, trainees were required to engage with reading and research in order to supplement any gaps in their knowledge.

Research suggests that for practice to develop trainees need to reflect upon the outcomes of their teaching and be willing to make adaptations (Hagger et al, 2008; Loughran, 1997, Moon, 2004). Fifteen of the trainees indicated that this process provided them with the opportunity to draw together aspects of theory and practice. As discussed in Section 4.2 trainees formulated refinements to their own mathematical practice by drawing upon pedagogical theory gained from both the school setting (formal and informal discussions and observations of good practice) and centre-based training. Trainees needed to be encouraged however to consider both the 'how' and 'why' aspects of theory. Deep mathematical understanding was developed when trainees were able to progress beyond finding solutions to problems and towards an appreciation of why particular pedagogical choices were necessary. Centre-based training in mathematics was also important in providing solutions beyond the specificity of the school setting. Centre-based training provided an opportunity to engage directly with the theory related to children's mathematical learning, alongside practical engagement with resources and pedagogical approaches. Additional theory and practice was also generated when trainees shared and reflected upon their own experiences within centre-based training sessions. Gaps in knowledge were addressed when trainees were proactive in seeking out theory through the engagement with background reading.

The impact that theory and practice had on trainee development will now be considered in more detail.

6.4 The impact of theory and practice on trainee development

Within the July questionnaire, trainees were asked to consider which aspect: theory, practice or a combination of both, they perceived had the biggest impact on their development of mathematical PCK during the training year (See Appendix P). Thirteen of the eighteen trainees indicated that it had been a combination of both, whilst the remaining five identified practice as having the biggest impact. An analysis of the trainees' explanations about why particular theoretical and practical aspects had an impact highlighted the perceived interlinking roles that both aspects play in trainee PCK development.

For theory overall there was no clear indication of whether this was gained within the centre-based or school setting. What was clear however was a shift in the trainees' perceptions of how theory will develop their mathematical pedagogical knowledge. This gaining of knowledge was now more largely linked to understanding the 'why' of teaching rather than the over-riding focus on the 'how to teach' aspects seen within data gathered at the start of the training year (See Section 6.1):

'Theory provides the reasoning' (EBITT trainee 4)

'Now have a deeper understanding of the process of learning skills.' (EBITT trainee 17)

This could be seen as a shift away from the proceduralist apprentice (Hobson, 2003), with trainees wishing to develop an understanding of the rationale behind their actions.

This development could be linked to the stages of trainee development (Fuller & Brown, 1975; Furlong and Maynard, 1995; Russell, 1988) where trainees enter the latter stages in which they no longer focus solely on their survival and performance as a teacher within the classroom as their confidence has grown. Rather they are able to focus on their role as facilitators of mathematical learning. This transformation led to a desire to understand more

fully the ways in which learning can be facilitated, any potential barriers to this process and how they can be overcome – an aspect that theory can provide. This development away from an initial mimicking stage of teaching was recognised by one trainee,

'Modelling what my mentor did was all very well, but I needed to understand why it was the correct way to go about it.' (EBITT trainee 6)

This illustrated the trainee's developing recognition that in order to fully develop as an effective teacher, they must reach a true understanding of why particular pedagogical approaches are effective. This allowed them to make informed choices in relation to the teaching situation and the pupils' needs.

In one case the trainee highlighted how their preferred learning style may have impacted on their ability to make connections between the somewhat abstract and distant from actual children nature of centre-based training, and the real-life practical experiences within the classroom. When asked to consider the aspect of the training year that had the biggest impact on their development of mathematical PCK, EBITT trainee 5 reflected that,

'It was hard for me to see how I could put the theory into practice – watching actual teachers in actual classrooms impacted much more. I can be told ten times how something will work but I only need to see it once.' (EBITT Trainee 5)

This emphasised the importance of observation of good practice in enabling trainees to see first-hand effective pedagogical approaches within mathematics lessons. However this learning may be superficial if the trainee is not able to reflect upon the reasoning behind the teaching approaches and examine, ideally alongside an experienced practitioner, not just what was done, but why it worked and how it can then be applied to the trainee's own teaching (See Section 5.4). Links to theory needed to be drawn.

If this theory is only developed however within the context of one school setting, there is a danger that this specific learning (Edwards & Protheroe, 2003; Hascher et al, 2004; Loughran & Russell, 1997) cannot be transferred into a new setting. Centre-based training and practice within a second school (See Section 4.4) during the training year provided trainees with the opportunity to widen their theoretical perspectives on effective mathematical PCK.

A link between practice and reflection was highlighted by four trainees, with a belief that this process would enable the development of their teaching, '*Through my teaching I was able to reflect on success and how to improve.*' (EBITT Trainee 18) and also the learning of the pupils, '*Constantly adapting my practice to ensure the best possible progress is made by pupils.*' (EBITT Trainee 19). For two of these trainees theory was linked explicitly to this reflective process with it being utilised to offer explanations and alternatives.

There was evidence that it was the practical aspects of teaching that had the biggest impact on trainees' confidence levels within the teaching of mathematics. Practical experience provided trainees with the opportunity to experiment and hone their pedagogical skills and the success that they experienced, and positive feedback provided by observers, led to enhanced confidence levels. At the same time this success in practice would be limited without the theory that equipped trainees with the knowledge and understanding that allowed them to understand and cater for the children's needs using a wide repertoire of strategies. The analysis of data from this research indicated that there was a critical relationship between theory and practice, with both being necessary for the development of true understanding of mathematical PCK. Theory was given meaning when it was enacted and reflected upon within the classroom, and practice was enhanced when the trainee was able to draw upon a range of theoretical perspectives, both extending their repertoire of teaching strategies and their understanding of how children learn.

It was necessary therefore to question whether there was an optimal balance of theory and practice within the ITT training year.

6.5 Is there an optimal balance?

After considering all aspects of the ITT training year, both in the school and centre-based setting, that can be perceived as having an impact on the development of mathematical PCK data from this research indicates that both theoretical and practical elements are vital in order for a trainee to develop into a confident teacher of mathematics – to be able to progress learning with a depth of understanding. Whether there was an optimal balance was an important consideration in light of the development nationally of differing routes into qualified teacher status, including a shift towards greater school-led provision (DfE, 2011). It could be argued that the most effective model was not one in which a greater responsibility for initial teacher training was placed upon schools. This shift into schools could lead to a dilution of the theoretical components, with these aspects becoming overly school specific and lacking in breadth and depth as they are undertaken by school-based practitioners who may not have the knowledge, understanding and time to deliver them to a level at which trainees are extended and challenged.

An analysis (See Section 3.7.1) of the July questionnaire data provided an insight into the particular aspects of the training year the trainees perceived to have had the biggest impact on their development of mathematical PCK (See Table 7 overleaf). This highlighted the overall impact of school-based experiences in developing trainees' mathematical PCK. For 100% of the trainees the practical experience of planning, teaching and assessing in mathematics had a high level of impact on their development. Alongside this school-based experiences including discussions with practitioners, feedback from observations, reflections

on teaching experiences and observations of good practice were seen as having a high impact.

The importance of school-based elements of the course was also demonstrated through an analysis of the trainees’ response to the question, ‘Describe the learning situation which had the biggest impact on your development as a teacher of mathematics this year’ (See Appendix P) in which thirteen of the eighteen trainees indicated that a teaching situation had brought about the highest level of impact on their development as a teacher.

Aspect of the training year	Number of trainees rating the impact as higher than average n=18	
	EBITT n=12	PgCE n=6
Practical experience of planning, teaching and assessment in mathematics	12	6
Own reflections on mathematics teaching	9	5
Discussions with practitioners – mentor, class teacher and/or mathematics subject leader	9	4
Feedback from observations in mathematics	9	5
Observations of good practice in mathematics	8	4
Mathematics Centre-based training	8	3
Private research	5	2
Discussions with other trainees	3	1

Table 7: Trainees’ perceptions of the level of impact of aspects of the training year on their development of mathematical PCK

It was within the classroom that trainees were able to implement a range of pedagogical strategies and make decisions that impacted on pupils’ learning. It was through school-based experiences that trainees enhanced their knowledge and understanding in a real-life context, and the success that they experienced, alongside the feedback that they received, enhanced mathematical PCK confidence levels. However without some form of theoretical

underpinning I would argue that this development was likely to be slow and there was the risk that the trainee would be confined by the specificity of the context of the school in which they worked. Gaps in knowledge and understanding may exist if trainees are reliant on learning solely through trial and error within the classroom setting. Without an engagement with theory, trainees' learning may be purely surface, leading to a limited understanding of children's learning needs and difficulties that may arise when responding to barriers to learning.

It could be argued that theoretical knowledge and understanding can be developed alongside practice solely inside the school setting. Within the community of practice, trainees can be provided with opportunities to engage with theoretical perspectives through their reflective observations of good practice, their discussions with skilled practitioners, including subject leaders and mentors, and their personal reflections in which they are encouraged to consider the reasoning behind events in the classroom. Evidence indicated that these learning opportunities are taking place within schools in this study. However the depth of development that took place was dependent on factors within the school setting:

- The ability of the experienced practitioner to articulate their own understanding of mathematics teaching and learning, including that which is tacit.
- The availability of quality time for learning discussions to take place
- The skill of the observer in pinpointing particular features of mathematical pedagogical practice within lesson observation feedback and encouraging the trainee through reflections to offer a rationale for these aspects. Alongside this an ability and willingness of the observer to encourage and develop the trainee's ability to reflect in-depth on their own practice and suggest steps to enhance their own practice and the children's learning.

- A willingness of the trainee to be proactive in their own learning, and seek out ways in which to develop their practice through engagement with a range of theoretical perspectives.

The success of these factors can be dependent on both time constraints that may be placed on the mentoring role and limitations in the theoretical knowledge base of school practitioners working with trainees. This could lead to training and cost implications for schools, mentors and subject leaders working with trainees. Furthermore, if training takes place solely in the school setting, the trainee will be excluded from the opportunity, provided through centre-based training, to gain a wider range of perspectives beyond that of the specificity of their school and class setting. This could lead to a deficit in the trainee's knowledge if they move to a different school or age phase setting, resulting in potential difficulties and a loss of confidence if they struggle to adapt to the new learning situation.

Evidence from this study demonstrated the importance of theoretical underpinning provided by centre-based training in mathematics. Through this trainees developed a depth of understanding of the reasoning behind a range of mathematical pedagogical approaches. This was across the full primary 3-11 age range, thus providing a full understanding of pupil progression. Possible misconceptions and barriers to learning were identified and strategies explored. In the school setting potential inconsistencies in the importance placed on theoretical engagement could lead to a situation where this learning is left to chance and only occurs when the need arises.

This study highlighted how theory and practice complement each other. Theory gained at the centre was drawn upon within planning and teaching lessons, and allowed the trainee to reflect in and on-action, and provided them with the confidence and knowledge to make necessary changes to their practice. Mathematical pedagogical knowledge gained from the

tutor and from discussions with their peers was utilised and enhanced the trainees' teaching repertoire, enabling them to extend beyond the specificity of one school.

The analysis of data within this study indicated that as the training year progressed trainees began to perceive differently the theoretical elements of the course, valuing the opportunity to not only develop a repertoire of teaching strategies and bank of resources, but alongside this a deeper understanding of pedagogical approaches and the impact on children's learning. Using Hobson's (2003) model there was evidence that trainees moved away from a proceduralist apprentice approach (See Section 6.1) towards either an understanding-oriented learner or education-oriented apprentice. This transition was signaled by a growth in the trainees' awareness of the importance of the development of an understanding of the theory behind pedagogical practices within mathematics. This deeper understanding was both utilised and scrutinised, within reflective practice, leading to an enhancement in children's learning and an increase in trainee confidence. After analysing the data it became clear, that for this particular provider, as it has a school-centred approach, trainees are most likely to display an education-oriented approach (Hobson, 2003) to learning to teach – one in which they valued the opportunity to develop theoretical knowledge but believed that it was in the school setting that most learning took place.

The mathematics tutor suggested that both routes are effective in developing confident teachers of mathematics but in different ways and rates,

'The EBITT trainees are more confident in the spring term as they have taught more. They have more opportunities to try things out and reflect with their mentor. Doing things you learn what went wrong and you can then analyse what you can do to improve this. PgCE trainees don't have the same amount of time to do this. By the end of the year however this has balanced out as the PgCE trainees have more theoretical input and this develops their skills and confidence.'

So is there an optimal balance between school and centre-based training? This is difficult to define, as it is dependent on the quality of the support and theoretical engagement of the school. What was clear however was that opportunities to engage with theory alongside practice are vital. This was a particularly important consideration in view of the shift towards more school-led routes into Qualified Teacher Status. The Initial Teacher Training Criteria (National College for Teaching and Leadership, 2015) outlined the minimum expectations for time to be spent within the school setting, but there were no guidelines for the provision of theoretical training. The concern could be that schools, particularly those engaging with the School Direct (salaried) route, in which trainees are employed as an unqualified teacher for the duration of the training year, may expect trainees to fulfill the role of a class teacher from the outset, with limited opportunities to engage with theory outside of their own setting. The potential consequences of this being a generation of teachers who are working in classrooms but lacking breadth and depth of understanding about how children learn and why pedagogical approaches in mathematics are effective.

Chapter 7 – Conclusions and recommendations

This chapter draws upon findings of this study, providing an overview of conclusions in relation to the research question and each line of enquiry. This includes recommendations for practice within initial teacher training, alongside suggestions for further research that could be undertaken. Limitations of this study are acknowledged and any unique contribution that my research makes to the existing body of knowledge in this area is highlighted.

7.1 – Conclusions

This study explored the ways in which primary trainee teachers develop their mathematical pedagogical content knowledge during the initial teacher training (ITT) year. A collective case study approach examined the experiences of trainee teachers following two different routes into qualified teacher status: Employment Based Initial Teacher Training (EBITT) and the Professional Graduate Certificate in Education (PgCE) route within the ITT provider in which I work.

The following lines of enquiry were defined:

- What is the role of the school, and school-based training in developing trainees' mathematical PCK?
- What is the role of centre-based training in developing trainees' mathematical PCK?
- To what extent is centre and school-based training interlinked in supporting the development of mathematical PCK?
- Which elements of the training year do trainees perceive to have the greatest impact on the development of their confidence in mathematical PCK?

Each of these aspects will now be addressed.

7.1.1 What is the role of the school setting in developing trainees' mathematical PCK?

In my study, training within the school setting was seen as having a high level of impact on the development of trainees' mathematical PCK. Within schools trainees undertook a range of teaching and training activities; being required to engage, with increasing responsibility, in whole class planning, teaching and assessment in mathematics (See Appendix A). This learning through experience (Hagger et al, 2008; Hobson, 2003; Mutton et al, 2010) was seen as having a high impact on the development of mathematical PCK and was enhanced through reflective practice (See Section 4.2). During teaching experiences trainees were able to draw upon and trial a range of teaching strategies to support pupils' development of mathematics. These strategies were gained from a variety of sources including centre-based training sessions; discussions and working alongside colleagues; observation of good practice, and private research.

The level of success of these teaching experiences had an impact on trainees' development and confidence levels in mathematics (See Sections 4.2 and 6.4). Through assessment of pupils' learning and reflective practice trainees were able to identify whether a particular pedagogical approach was successful in moving children's mathematical learning forward. If it was, then the trainee chose to assimilate it into their developing repertoire of teaching strategies (See Section 4.2). If the strategy was unsuccessful, for either groups of children or the whole class, then the trainee was required to make decisions about alternative approaches that could be utilised. In the early stages of trainee development (Britzman, 2003; Fuller & Brown, 1975) when the trainee may be lacking in knowledge and/or confidence, these adaptations in response to the pupils' needs may be made following the lesson - reflection on-action (Schön, 1987). As the trainees' knowledge of teaching strategies increased during the training year, they became more adept at planning effectively

for pupils' learning needs, and were able to reflect and make pedagogical choices in-action (See Section 4.2).

Simultaneously, these teaching experiences developed the trainees' knowledge and understanding of pupil progression in mathematics (See Section 4.3). Through the teaching of a series of mathematics lessons trainees became more aware of how the learning needs of pupils within their class could be met. This knowledge was also gained through the observation of other teachers teaching the class (See Section 4.1.6). Understanding of progression allowed trainees to plan successfully for pupils' needs as they gained a clearer awareness of prior learning and necessary next steps. Trainees were also able to anticipate particular misconceptions and difficulties the pupils may encounter and plan to address them. This aspect was seen in this study (See Section 4.3) to be strongly linked to confidence levels in mathematical PCK, with trainees feeling that they were successful within the classroom if they were able to effectively meet the needs of all of pupils. It could be argued that PgCE trainees are disadvantaged as they only complete 6-week teaching practices within one setting, compared to EBITT trainees who remain with the same class for the whole of the training year and are therefore able to see progression over the long-term, developing a depth of understanding of the pupils that they teach. However from my data I would argue that the additional theoretical knowledge PgCE trainees gain about pupil progression in mathematics within centre-based training provides a level of background knowledge, which trainees can draw upon, accelerating their ability to respond to pupils' needs once they enter the school setting.

My data showed that the support structure within the school setting was perceived by trainees and mentors (See Section 4.1.4) as being of great importance; enabling the trainee to be assimilated into the community of practice (Lave & Wenger, 1991; Mutton et al, 2010) through opportunities to work alongside, observe and conduct discussions with colleagues.

Feedback on lesson observations (See Section 4.1.5) was seen by respondents, as a crucial aspect of PCK development, with positive feedback leading to an increase in trainees' confidence. Trainees valued the opportunity, through formal discussion and observation feedback reports, to gain: ideas and strategies to utilise within future teaching, targets to support their continued development and the opportunity to engage in reflective dialogue. The scrutiny of mathematics lesson observation reports indicated that specific mathematical aspects were addressed somewhat as part of lesson observation feedback, but the extent to which mathematics was focused on compared to more generic issues was unclear and this may have varied across schools and observers. One of my recommendations would be that the degree to which mentors' oral and written feedback to trainees focuses on aspects of mathematical specific pedagogy is an area that could benefit from further research. Additionally it would be advantageous to consider the value of subject specific mentoring within the primary school setting.

This study established that trainees perceived the observation of good practice to have a significant impact on their mathematical PCK development (See Section 4.1.6). They valued the opportunity to gain additional ideas and teaching strategies, and by engaging with a range of practitioners, including the mathematics subject leader (See Section 4.1.8) trainees were able to come to the realisation that teaching can be approached in a range of ways. Trainees reflected on these observations and then made decisions about which aspects to assimilate into their own practice. This provided trainees with the opportunity to re-examine perceptions about the teaching of mathematics and engage with alternative images of good practice. Trainees can come into teaching with a negative view of mathematics, often due to their own experiences as a learner as a child (See Section 2.4). The opportunity to engage with current good practice through observations allowed trainees in this study to view mathematics as engaging, investigative and practical, and different from the textbook and formal methods they reported experiencing in their schooling (See Section 4.1.6).

Research (Pinder, 2008; Zanting et al, 2003), suggests that trainees gain most if they are provided with the opportunity to engage in reflective dialogue with the teacher following an observation. Within this study it appeared that trainees did not always get this opportunity and when it did occur it was often informal. This opportunity needs to be developed to enable a depth of learning and understanding of pedagogical approaches to take place. For this to occur however it must be recognised that teachers working alongside trainees are often time-poor (Hudson & Hudson, 2011), having to fulfill a range of other important roles alongside that of a mentor. I would recommend that mentors be provided with dedicated time during the school week in which to conduct their role, so that they can undertake high-level reflective conversations, in which they encourage trainees to draw upon a range of school and centre-based mathematical sources to articulate and explore their own understanding and learning; finding solutions to challenges and developing their pedagogy and in-turn the pupils' learning.

This study established that within the school setting the class teacher is often seen as highly valuable in supporting trainee development, as a result of the ongoing everyday support they are able to provide (See Section 4.1.7). This support included the modelling of good practice, a sounding board for ideas and the provision of advice. The class teacher was able to provide specific information about the mathematical learning needs of the class the trainee would be working with, so leading to a high level of impact in relation to the development of the trainees' knowledge of pupil progression. The vested interest that the class teacher had in the learning of the class also meant that they were keen to offer support so that mathematics lessons are well prepared and effective. At the same time however some trainees felt constrained by the presence of the class teacher, believing that there was an expectation that they teach the class in the same way as they do (Beck & Kosnik, 2000; Mutton et al, 2010; Pinder, 2008). This could be seen as having a detrimental effect on pedagogical development as the trainee may feel they don't have the freedom to experiment with a range of strategies. I would recommend that class teachers offer support

and guidance in the early stages of training, but move outside of the classroom setting later in the year, thus giving the trainee freedom to innovate and reflect independently. This will lead to the development of a wider repertoire of mathematical PCK and increased confidence when the trainee experiences success, thus preparing them for qualified teacher status and the independent role of class teacher.

7.1.2 What is the role of centre-based training in developing trainees'

mathematical PCK?

Centre-based training was seen in my study as having a high level of impact on the development of trainees' mathematical PCK (See Chapter 5). Firstly it enabled trainees to develop and extend their repertoire of teaching and learning strategies. Working alongside the expert mathematics tutor, they were able to engage with a range of practical activities (See Section 5.2), and through exploration and discussions with the tutor and peers they were able to develop an understanding of how children learn, the progression of children's learning across all mathematical subject areas (See Section 5.5) and also common misconceptions and difficulties. This experiential approach to learning was seen by the respondents to be of great value as it provided the opportunity to engage in reflection as they learned (See Section 5.2). This knowledge gained was considered to be more meaningful if experienced first-hand. Centre-based training provided a model of good practice within mathematics, allowing trainees to continue to formulate and reflect upon the views of mathematics they may have formed as a child (See Section 2.4.1). Additionally, centre-based training enabled trainees to move from the specificity of the age group in which they were working within, as they were provided with an overview of expectations and progression across the whole of the primary age range (See Section 5.5). As well as preparing trainees to potentially teach in a different age phase, this gaining of an overview of progression supported planning for differentiation. A broader perspective of learning across

the primary age range was also gained through peer discussions, in which pedagogical experiences from a range of age phases and schools were shared.

The exploration of a wide range of mathematical resources additionally allowed trainees in this study to broaden their pedagogical knowledge beyond that of the specificity of their school. The mathematics tutor was aware of the importance of ensuring that any resources that are shared are readily accessible to the trainees outside of the centre-based setting. There was evidence of trainees experimenting with these resources within their own school setting. As the training year progressed, trainees became adept (See Section 5.3) at making reflective choices in relation to which resources were most suitable for both the children within their class and their own teaching style (Malderez & Bodoczky, 1999).

The experiential approach to learning seen within this study, provided trainees with the opportunity to develop subject matter knowledge (SMK). Research (Goulding et al, 2002) suggests that confidence in SMK is interlinked with trainee's PCK, with strong SMK leading to more effective planning for mathematics lessons and an enhanced ability to respond to the pupils' needs in-action. By engaging in activities within centre-based training, trainees were able to revisit their SMK (See Section 5.2), including addressing misconceptions they may hold as a result of their learning experiences as a child. Centre-based training provided a supportive environment in which trainees were able to ask questions of specialists and their peers, away from the pressurised setting of the school.

7.1.3 To what extent is centre and school-based training interlinked in supporting the development of mathematical PCK?

In this study there were seen to be strong links between school and centre-based aspects of the course. Both aspects combined in a symbiotic relationship to develop trainees' mathematical PCK.

Centre-based training was seen by respondents in this study to support the reflective practice that took place within the school setting. Whilst carrying out observations of good practice in mathematics trainees were able to draw upon information from centre-based training in relation to how pupils learn and to offer explanations for events and teacher's actions within the classroom setting (See Section 5.4). Without centre-based training, trainees would merely see what is happening within the classroom, but not truly understand it. Centre-based training developed meaning and in doing so enabled trainees to reflect and make choices about assimilation into their own practice (See Section 6.3). The focus for observations may be derived from centre-based training, with trainees being motivated to observe, and subsequently put into practice the theory and ideas that they have learnt at the centre-base. For many trainees it was not until they saw the theory enacted within the classroom that they fully appreciated its meaning, purpose and benefits (See Section 5.4).

Whilst reflecting upon their own practice, trainees within this study were able to draw upon links with mathematics centre-based training (See Session 4.2). It offered explanations for why particular strategies were effective or not, and also provided a repertoire of ideas that could be drawn upon when targeting areas for development (Malderez & Bodoczky, 1999). This engagement with theory took place during post-lesson reflections, informing future planning and teaching. There was evidence that as the training year progressed trainees become more adept at reflecting in-action (Schön, 1987). Theory gained through a combination of centre and school-based experiences provided the scaffold that enabled trainees to have the confidence to execute on-the-spot decisions and make modifications to their pedagogical approach (See Section 4.2).

Although trainees were able to gain ideas about pedagogical approaches within the school setting through discussions and observations of good practice, centre-based training widened this repertoire beyond the setting of the school and class, leading trainees to make

informed decisions about what to draw upon within their mathematics teaching (See Section 5.2 and 5.3). Research (Beck & Kosnik, 2000; Mutton et al, 2010) suggests that trainees may be constrained in experimenting with their pedagogical approach by perceived expectations of the school and/or class teacher – a preference in respect to how mathematics is taught. In this study however this did not appear to always be the case, with evidence that trainees were given the freedom to experiment with a range of ideas gained from the school and the centre. This led in some instances to an impact on whole school policy, when ideas introduced by the trainee were adopted within the wider school community, as they were seen as new and innovative practice (See Section 5.3).

These strong links between theory and practice appeared to cause a symbiotic relationship to be formed in which both aspects combined to enhance the whole learning experience of the trainee (See Chapter 6). Each aspect had an important role in supporting the other, with a depth of knowledge and understanding of mathematical PCK attained, as trainees were able to draw links with the other, as they engaged in planning, teaching and reflective practice. Theory was given meaning when it was enacted and reflected upon within the classroom, and practice was undertaken with understanding when links with theory were drawn upon both following and within practice.

7.1.4 Which elements of the training year do trainees perceive to have the greatest impact on the development of their confidence in mathematical PCK?

An analysis of data from this study indicated that successful planning and teaching of mathematics within the primary classroom had the greatest impact on the confidence level in mathematical PCK of all trainees in this study (See Section 6.4). Through the teaching of effective lessons, in which pedagogical strategies applied brought about pupils' learning, trainees were able to gain satisfaction and this increased their confidence level (See Section 4.3). However I would conclude that this level of confidence was enhanced through

engagement with theoretical elements encountered within both the school and centre-based setting. Without this, trainees' understanding of mathematical PCK would have been limited – they may have been able to action things within the classroom but with limited awareness of why things are so. A depth of understanding enabled the trainee to make informed reflective pedagogical choices. Centre-based training allowed the trainee to engage with a wider range of mathematics teaching strategies and resources and this allowed them to broaden their horizons away from the specificity of their school setting – enabling a greater degree of transference.

For EBITT trainees in this study, the opportunity to apply their mathematical skills within another school setting had a great impact on the development of their PCK and confidence levels (See Section 4.4). Through moving away from the comfort zone of their preferred age range and base school trainees were required to develop their skills – revising and extending their approaches to teaching in response to the needs of a new group of children. Although this was challenging and at first daunting, the trainees' confidence was boosted when they were able to experience success and receive confirmation from a different mentor that they were effective in their teaching. They also came to realise that what they had learnt could be transferred, and that they could function as an effective mathematics teacher in a different setting. New skills learnt in this second school setting were also transferred back to the base school, so enhancing teaching there.

This study established that in increasing their repertoire trainees were able to become innovative in their approach to the teaching of mathematics, and in doing so were able to form their own identity as a teacher of mathematics (See Section 4.3). This development was individualised, with trainees passing through stages during the training year (Fuller & Brown, 1975; Furlong & Maynard, 1995; Russell, 1988). Trainees in the early stages sought out and used somewhat ad hoc, resources and strategies from the school and centre-based setting that were proven to be successful (See Section 4.1.7). As trainees developed, their

increasing understanding of how children learn and their reflections on the particular needs of their class, led to a more refined pedagogical approach, with more informed and personalised decisions about the teaching of mathematics being made (See Sections 4.3 and 6.2). This depth of understanding was enabled through the combining of theory – generated through reflective school and centred-based experiences – and practice in which experiential learning took place alongside reflections both in and on actions. This was a symbiotic relationship in which theory and practice complemented each other, and this in turn enhanced the trainees' confidence and mathematical PCK.

7.2 Unique contribution to existing knowledge

Extensive research has already focused on the development of pedagogical content knowledge (See Section 2.3), and the particular ways in which trainee teachers learn (See Section 2.4), including the value of learning through practice, the importance of reflection (See Section 2.7), and the role of the mentor in supporting this development (See Section 2.6). This study is unique in that it focuses on the development of mathematical PCK in trainees following two particular routes into qualified teacher status. Although this was not a comparative study this approach allowed me to study trainees immersed in the community of a single school for the majority of the training year, alongside trainees completing teaching practices within two school settings but experiencing more centre-based theory. This offered me a richer set of data on which to draw conclusions, and enabled me to analyse the impact of the theoretical and practical components of mathematics training within this provider. This led to the conclusion that there is a symbiotic relationship between the two, with each supporting and enhancing the other. Each aspect is necessary if the trainee is to develop a depth of understanding about how children learn mathematics, including potential difficulties and how these may be overcome. The inclusion of theoretical components explored outside of the school setting ensured that trainees are able to move away from the specificity of one class or school setting.

7.3 Limitations of this study

In undertaking this study I was conscious of the demands of part-time doctoral work and the limited window in which to undertake my research. However through integrating my research with my professional role I have been able to gain a good insight into the factors affecting the development of mathematical PCK. This study was also undertaken at a time of volatility within the ITT sector. I have endeavoured to align my research with changes that have occurred, and have been able to relate my observations to the emerging school-led approach to ITT.

I was aware of the limitations of drawing findings from small numbers with my sample size being 26 (Cohen et al, 2006). Increased participation would have enabled a wider perspective to be drawn and increased validity to my data and conclusions. Greater generality could also have been gained through the gathering of data from a range of primary ITT providers, so moving away from specificity of one case. However I would argue that the mixed method approach that was followed allowed for a depth of data to be gained and tested. The quantitative questionnaires identified lines of enquiry that were then developed through group interviews. Additionally my insider practitioner knowledge allowed me to fully contextualise the data.

In view of the changes to ITT that have occurred during this study it would be valuable to extend the methodology of this study to the School Direct scheme (See Section 1.4). This approach is now embedded within many schools, working in partnership with ITT providers. Research could be undertaken in which the perceived theoretical and practical elements of the training year are examined, including the roles of the key partners. This could include a comparative evaluation of data in which any shift in responsibility for trainees' learning and development is explored, including the possible implications of an increased proportion of training being undertaken within the school setting. The balance between theory and

practice and the potential subsequent impact on the development of trainees' mathematical PCK could be examined.

I could have conducted this study differently by extending my study into the newly qualified teacher year. This would have allowed me the opportunity to track the trainees' perceptions in relation to the extent that the training year had prepared them to confidently teach mathematics as a full-time qualified teacher. In cases where trainees have secured a teaching position in a school different to that in which they trained this would have provided me with the opportunity to investigate the transference of pedagogical skills into a new setting. This will be something I undertake as follow-on research in my professional role.

Many aspects of this study could have been researched fully in their own right. Further lines of enquiry to triangulate my data could have included:

- An examination of the content of trainees' reports on their observations of good practice in mathematics. This would have allowed an opportunity to examine the aspects that trainees focus on, the ways in which this links to PCK and the extent to which trainees are able to analyse good practice and apply this to their own practice
- Observing mathematics observation feedback discussions that take place between trainees and mentors. This would have allowed an enhanced analysis of the ways in which specific mathematical PCK is addressed and also an opportunity to consider the ways in which mentors support trainees' learning – is it didactic or does it encourage reflection?
- The impact of trainees' academic qualifications in mathematics on their confidence levels and PCK. This could include an exploration of the ease to which trainees with

a high level of academic achievements (A-level or degree in mathematics) are able to utilise this subject matter knowledge within their pedagogical approaches in the primary classroom. This could be extended to include the confidence levels in the classroom of mature trainees who have taken GCSE mathematics as an adult.

7.4 Impact on my own professional practice

Through this study I have developed my understanding of the ways in which trainee teachers develop their pedagogical knowledge within mathematics. The importance of the inter-relationship between the theoretical and practical elements of the course have come to the fore, including the transformation of trainees' views of theory as they progress through the training year and become more focused on pupils' learning needs. My study has highlighted the strengths of the centre-based elements of the course, but has led me to question how theory can be enhanced within the school setting. This has included a consideration of how the theoretical elements of teaching can be made more explicit, including a stronger focus within discussions between trainees and current practitioners, including mentors. This has led to a refinement of mentor training in which the ways in which trainees learn, the stages of their development and the importance of theory and its inter-relationship with practice are discussed. A particular focus has been the use of questions within feedback discussions with the aim that mentors will become more confident in probing deeply into their trainee's understanding of pedagogical practice. The value of current practitioners sharing their own pedagogical understanding has been highlighted, with a view to this being shared when analysing the good practice of the trainee and others.

7.5 Professional Recommendations

In light of my findings in this study I would make the following professional recommendations with the view to impacting on the practice of others within the initial teacher training sector:

- i. That it should be mandatory that all trainees undertaking school-led training be provided with opportunities to engage with mathematics centre-based training outside of the school setting.

This will ensure that they have the opportunity to engage with the “knowledge of why” within teaching, including why children learn in particular ways and how strategies support this learning, and why children experience particular difficulties or misconceptions within mathematics. Alongside this it will provide the opportunity to extend trainees’ “knowledge of how” to teach particular aspects of mathematics. Through engagement with an expert mathematics tutor and their peers, trainees will be able to extend their repertoire and understanding of a wide range of mathematical strategies and resources beyond the specificity of one school.

- ii. That mathematics training within the centre-based setting should follow an experiential approach

Hands-on engagement with teaching strategies and resources alongside their peers and outside of the school setting, will enable trainees to experience and reflect upon the value of approaches and develop a deeper understanding of how they support learning. This will enable a move away from a trial and error approach to teaching, in which pedagogical approaches are experimented with solely in the classroom. This opportunity for exploration and reflection prior to teaching will allow trainees to develop a better understanding of potential difficulties that children may encounter and consider how these may be addressed, allowing them to make more informed pedagogical choices both in the planning process and in-action within the classroom. This engagement within the centre-base will allow trainees to consider their perceptions of mathematics teaching, ensuring that they gain an understanding of good practice.

- iii. It is vital that links between theory and practice are drawn upon during all elements of the training year

As discussed in Chapters 6 and Section 7.1, the inter-relationship between the theoretical and practical aspects of the course is vital if a trainee is to develop a depth of knowledge and understanding of mathematical PCK. Trainees should be made aware of the value of making links with theory from the outset of the training year, so that they are willing to consider in greater depth the reasoning behind their own and other's actions within the classroom. This will allow them to make informed choices within both the planning and teaching process. At the same time centre-based tutors should provide trainees with the opportunity to reflect upon and share with their peers examples of classroom practice within training sessions. In such discussions trainees should be enabled to engage in analytical conversations and debates in which pedagogical approaches are examined in-depth, so that it is extended beyond purely the sharing of techniques - moving towards an understanding of ideas and approaches. School-based mentors must also receive information about the focus of mathematics centre-based sessions, so that they can follow-up on discussions during meetings with their trainees. This will allow trainees the opportunity to consider this theory within the practical context and the specificity of their school.

- iv. Lesson observation feedback and discussions should contain some focus on the pedagogical content knowledge of the subject area being observed.

Observers should extend their feedback and discussions away from generic pedagogical and class management issues and towards the specific characteristics of the subject area being taught. This will allow trainees to reflect upon and develop their understanding of the features that are unique to the subject. Through this a depth of pedagogical knowledge will be achieved, enabling the trainee to respond appropriately in the future to the particular

needs of pupils. A specific box on the lesson observation report proforma will direct the observer towards making such a comment and make it a feature of feedback discussions.

- v. Time should be allowed for trainees and teachers to discuss the good practice that has been observed

Trainees must be provided with opportunities to observe good mathematical practice throughout the training year. It is imperative that this continues beyond the first term, as later in the training year trainees have a greater awareness of what they need to observe; understand what they are observing and can prioritise observations to focus on particular target areas. Observation of good practice is vital as it enables trainees to be reflective and make decisions about what they will apply in their own practice, however it will be enhanced if it is accompanied with an opportunity for a follow-up discussion on what has been seen. These discussions will provide an insight into the teacher's thinking and the reasoning behind the particular pedagogical decisions that were made both before and during the lesson.

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Appendices

Appendix A – Overview of Routes

Training route	Employment Based Initial Teacher Training (EBITT)	School-centred Initial Teacher Training (SCITT)
Status	Employed as an unqualified teacher within a training school	A full time student
Entry Requirement: Previous experience	At least <u>6 months</u> experience within a school setting required prior to application	A minimum of <u>2 weeks</u> experience within a school setting, in a paid or voluntary capacity, prior to application
School-based training	<p>Individualised termly training plan put into place</p> <p><u>172 days</u> within school setting</p> <p>50% whole class teaching commitment in autumn term 60 – 70% whole class teaching in spring term 80% whole class teaching in summer term</p> <p>Teaching mainly within one age phase</p> <p>4-week teaching practice within an alternative age phase and school in spring term</p>	<p>Teaching practices in line with expectations set out in generic handbook</p> <p><u>90 days</u> within school setting</p> <p>7 weeks teaching experience during autumn term within 3 age phases (at least 2 schools). Limited teaching – groups and some whole class</p> <p>6 weeks teaching practice during spring term within 1 age phase. 50% whole class teaching</p> <p>6 weeks teaching practice in summer term within another age phase 80% whole class teaching</p>
Centre-based training	23 days in total	80 days in total
Focusing on subject knowledge per se and pedagogy	5 x 3 hour sessions in mathematics (15 hours)	20 x 3 hour sessions in mathematics (60 hours)

Appendix B – Glossary of acronyms in initial teacher training

DfE	Department for Education
EBITT	Employment Based Initial Teacher Training
GT	Graduate Teacher
ITT	Initial Teacher Training
OFSTED	Office for Standards in Education
NCTL	National College for Teaching and Leadership
NQT	Newly Qualified Teacher
PCK	Pedagogical Content Knowledge
PgCE	Professional Graduate Certificate in Education
QTS	Qualified Teacher Status
SCITT	School-centred Initial Teacher Training

Appendix C - Definitions of post-graduate routes into Qualified Teacher Status

Higher Education Institutions (HEI) – Universities offer a combination of academic learning and teaching practice placements in at least two schools. This leads to the award of Qualified Teacher Status (QTS) and a Post-graduate Certificate in Education (PGCE), with credits at masters Level.

School-centred initial teacher training (SCITT) – Networks of schools who have been approved by the Department of Education to provide training and the recommendation for the award of QTS. Experienced current practitioners, who are working in a school in the network, often provide training. SCITTs may work with a HEI provider to offer a PGCE and/or credits at masters level.

Employment Based Initial Teacher Training (EBITT) – Trainees are employed as an unqualified teacher for the duration of their training year. A HEI provider or a SCITT will provide training and the award of QTS. The expectation however is that a large proportion of the training will occur within the school setting with the trainee 'learning on the job.' Trainees may be able to complete a PGCE and/or gain credits at masters level through working with a HEI. This route was previously known as the Graduate Teacher route (GT) and from 2013 has been referred to as the School Direct (salaried) route.

Appendix D - Trainees' rationale for choosing a particular ITT route

PgCE 1 – More being taught the different teaching strategies and then putting it into practice after that rather than going straight into it without getting taught.

PgCE 2 – I looked into the 2 options that were available and I was told that for the GT route I would need to get a lot more work experience within school. I was looking at starting it in the following 6 months so the PgCE route was the best way as I already had a degree as well. Actually now I think the most difficult thing is going into different schools and being thrown in and quickly having to learn the ways each school works. Although I know the GTs do a shorter placement I think that's what's really good about this one. I think it's developed me more than anything.

PgCE 3 – I wanted to do the GTP because of financial reasons, but looking back I wouldn't have been able to cope with it because I wouldn't have the experience of teaching, so this definitely has been the best way. Also separating my previous work with children and restructuring the way I think about things.

PgCE 4 – The benefits of the lectures and the teaching experience running alongside each other. The GT route is very much in-school based and I think that with my previous experience being so limited with teaching, it obviously wasn't appropriate for me to go for that route but for me personally PgCE gives you so many more strategies about how to teach it, and depending on which year you are teaching what is the appropriate curriculum you should be teaching. That for me was why I felt that this was the right route. It gives you a grounding so you are not going in blind, but with some grounding of this is the way I should be putting things across, and children need the practical side before you maybe get to the theory side.

PgCE 5 – I come from a similar thing, I hadn't had much experience of teaching prior to the start of the course, so the PgCEs long periods in school was what appealed to me, 6 weeks and 4 weeks and 6 weeks of constantly in there. I felt that it was the best way to get there and get the knowledge of how to teach and everything around it. So that was why I choose this.

EBITT 1 I chose this route because I needed to carry on learning while I was paid. I couldn't stop earning and do a PgCE. I expected that I would have the class teacher in a kind of

mentoring role. Observing her and then having some actual input with her opening her thinking and her processes up to me.

You said it was for financial reasons but if you didn't have money issues, would you have chosen the same route?

What I like is staying in the same school apart from the second placement. I don't know how many placements the PgCEs have but it would be starting again for short periods of time and you wouldn't have that long overview of the progress of the children which you do being in the same school.

EBITT 2 - I was recommended to become a GT as I had had previous experience of being a TA/cover supervisor. My head teacher felt that I had enough of the qualities of being a teacher to go onto a GT, understanding that you don't get as much support in terms of lecture classrooms as you would on PgCE, but felt that I had the basis to cope, and knowing how proactive I am in my own learning. In areas which I already considered to weaknesses I felt that there was already a strong support network within my school and Shire to be able to help. I think I am proactive and if I know I am lacking in something then I go to try and find it, and I am reflective on that. So the reason I chose the GT is because I am getting married in the summer and I couldn't afford to go on the PgCE. I was offered it and I said that if there were any other circumstances I would do it because I want to become a teacher. I was going to carry on in a school and develop myself as a person not just as a practitioner. So yes I would choose the same route because I like the way the course runs where you can learn on the job and you can gather the experience. As long as you are in a strong supportive school then you can get that support.

EBITT 5 – I chose this route because it fitted in with my lifestyle. That was a big development point for me and something I didn't plan for very well when I first tried to get on. I knew I had to spend a lot of time working on it on my own and a lot of time on it when I was in school.

EBITT 6 – The same reason for me. By then I had already spent 9 years in school as a TA, so it seemed a very comfortable way for me to do it. And it certainly has been so I am glad I have decided to do it this way.

It is a comfortable route – what do you mean by that?

EBITT 2 – I liked the idea, I have spent so much time in classrooms with children now, of doing it largely on the job. I didn't want to take myself outside of the teaching environment. I

found the course training really helpful, I learnt some surprising things as well, but I felt I would learn a lot from working alongside good practitioners, and that certainly has been the case.

Appendix E - Timeline for different stages of data collection

Year 1 – Pilot Study	November	<p>Ethical approval gained for study Study outlined to all trainees through an oral presentation at the centre. Participants written consent gained. Initial questionnaire completed by trainees.</p> <p>On-line forum discussions took place Analysis of questionnaire responses and lines of enquiry for interview stage identified</p>
	January	PgCE group interviews
	January – March	Trainee completion of reflective journal.
	February – March	Transcription of interview data.
	March	<p>Pilot questionnaire completed by mentors EBITT group interviews Trialling of funnelling process for interview data.</p>
	June	Review of pilot study data and processes. Lines of enquiry for year 2 confirmed. Data collection methods refined and amended for year 2
Year 2	November	<p>Study outlined to all trainees through an oral presentation at the centre. Participants written consent gained. Initial questionnaire completed by trainees.</p>
	January	Analysis of questionnaires to establish interview lines of enquiry
	March	<p>Group interviews – PgCE and EBITT cohorts. Questionnaire completed by mentors.</p>
	April	<p>Observation of mathematics centre-based training session Written lesson observations from mentors collated and analysed.</p>
	June	<p>Mentors interviewed Core tutor for mathematics interviewed</p>
	July	<p>End of training year questionnaire completed by trainees. Follow up lines of enquiry established. Group interviews – PgCE and EBITT cohorts</p>

Appendix F – Trainee Questionnaire

Development of Mathematical Pedagogical Content

Knowledge

November

1. Which training route are you following?

GT PGCE

2. What are the 2 age phases you will complete your training in?

EYFS KS1 Lower KS2 Upper KS2

3. Which qualifications do you have in maths? (Tick any which are applicable)

GCSE Grade C ☐ GCSE Grade B ☐ GCSE Grade A ☐ A Level Maths ☐ Maths Degree ☐

4. Please rate your current level of confidence in the teaching of maths (with 5 being the highest level of confidence)

1 (No confidence) ☐ 2 ☐ 3 ☐ 4 ☐ 5 (Highly confident) ☐

5. Please outline any experiences, as a child or adult, which you feel may have impacted (positively and/or negatively) on this level of confidence.

6. Please rate the level of impact (with 5 being the highest level of impact) the following has had so far on your development of mathematical pedagogical content knowledge

	1 (no impact)	2	3	4	5 (High impact)
Your own experience of learning maths at school					
Your own experience of teaching maths prior to the start of the course					
Centre-based training					
Private research and reading					
Observation of good practice					

Discussions with practitioners including mentor, class teacher and/or maths subject coordinator					
Discussions with other trainees about maths					
Feedback from observations of your teaching of maths					
Your own reflections on your teaching of maths					
Practical experience of planning, teaching and assessing in maths					
Academic tasks in maths (PGCE only)					

7. What was your role in a school setting prior to the start of this course?

Volunteer ☐ Teaching Assistant ☐ Nursery Nurse ☐ HLTA ☐ Unqualified teacher ☐

8. Describe the ways in which you were involved in the teaching of maths within this role?

9. In what ways do you feel this prior experience of the teaching of maths will impact on your confidence as a teacher of maths?

10. In what ways do you expect centre-based training to develop your knowledge of and confidence in the teaching of maths?

11. In what ways do you expect school-based practice to develop your knowledge of and confidence in the teaching of maths?

12. Describe the inter-relationship between the centre and school based elements of the course, in relation to the development of your knowledge of how to teach maths.

13. Consider each aspect of the course. Do you consider it to be theory, practice or does it contain elements of both?

	Theory	Practice	Elements of both
Centre-based training in mathematics			
Private research and reading			
Observation of good practice			
Discussions with mentor			
Discussions with class teacher and/or maths subject coordinator			
Discussions with other trainees about maths			
Feedback from observations of your teaching of maths			
Your own reflections on your teaching of maths			
Practical experience of planning, teaching and assessing in maths			
Academic tasks in maths (PGCE only)			

14. What do you understand the terms “theory” and “practice” to mean?

15. Describe the learning situation so far that has had the biggest impact on your level of confidence as a teacher of maths.

Appendix G – Interview Discussion Card

- Own experience of learning maths at school
- Observation of good practice
- Feedback from observations of your own teaching of maths
- Your own reflections
 - Reflection in action
 - Reflection on action
- Practical experience of planning, teaching and assessing maths
- Applying “theory” learnt in centre-based training in a classroom setting

Appendix H – Analysis of algebra centre-based training session

20	Trainees working in groups to develop patterns	Practical	PCK - Strategy
21	Trainees share ideas to the rest of the group	Discussion	PCK - Strategy
22	Trainees share ideas to the rest of the group	Discussion	PCK - Strategy
23	Trainees share ideas to the rest of the group. Trainees asked to describe what had happened to the pattern	Discussion	PCK - Strategy
24	Other ideas are suggested. Resources which could be used. Trainees are encouraged to share with each other examples of pattern work they have seen in school.	Discussion	PCK - Resources
25	Ideas are shared. Patterns are related to multiples – this is related to year groups. Counting cubes and then increasing to different numbers.	Discussion	PCK - Progression
26	Ideas are shared. Copy me song. This is demonstrated and the other trainees join in. Linked to the age group and the times of the day this is done.	Discussion and practical	PCK - Progression
27	Number patterns are explored.	Discussion	SK per se
28	Number card resources are distributed. Trainees to make themselves into a number pattern.	Practical	PCK - Strategy
29	Patterns are discussed and then the next steps are predicted.	Discussion	SK per se
30	Patterns are discussed and then the next steps are predicted. This is extended into number patterns and then multiples of 5. Discussed proving and predicting.	Discussion	SK per se
31	Where the activities can be bought is shared on the trainees' request.	Discussion	PCK - Resources
32	Further ideas are outlined briefly. Additional research is shared – Professor Ruth Merton – How the NC will change.	Tutor led	PCK – Curriculum expectations
33	Research is shared. Importance of patterns and generalisation in number. Insight into changes in the curriculum.	Tutor led	PCK – Curriculum expectations

Appendix I – Trainee consent letter

Dear Trainee

I am currently undertaking a Doctorate in Education (EdD) with The Open University. The working title of my research project is:

“Theory versus Practice: Comparing the development of mathematical pedagogical content knowledge of trainees following two routes into Qualified Teacher Status”

I am writing to you to invite you to take part in my study during the 2012-13 academic year. I want you to be as informed about the project as possible to help you make your decision, and I very much hope that you will feel able to take part.

What is the project about?

You will be aware that we offer two routes into Qualified Teacher Status: the PGCE and the GTP. One of the key differences between these routes is the structure of the training year, and in particular the percentage of time spent on the elements of school-based and centre-based training. Considering these differences, I am interested in researching how trainees across both routes develop their mathematical pedagogical content knowledge during the training year, and to what extent trainees on both routes feel prepared in this area, as they embark on their NQT year.

Extensive research already exists in relation to how trainee teachers “learn to teach”, but this study intends to examine a new aspect focusing on a comparison of two primary routes within the area of mathematics.

If you agree to take part, what will you be asked to do?

As you are currently enrolled on the course we hope that you will be able to contribute to this research. During the beginning and end of the year, you will be sent a written questionnaire to complete which will encourage you to reflect upon your training experiences in maths, both school and centre-based. This will take a maximum of half an hour to complete, and can be returned anonymously in an envelope. Trainees on both routes will also be invited to take part in more depth. This will involve taking part in a face-to-face group interview.

I would like to emphasise that taking part in the project at the simplest level does not necessarily commit you to further involvement. I hope that all trainees will be able to contribute at some level.

What's in it for you if you take part in the study?

First and foremost, it will be interesting! This is an important professional development opportunity as well as an important research study. Taking part will also encourage you to reflect on your own development and how you learn. The findings will impact on my research, but I hope that the information will also be utilised to review and shape future course developments – basically it will make the course even better!

I am aware that even participation at the most basic level will impact to some degree on your already heavy workload. I will therefore attempt to ensure that timings avoid the more intensive and stressful periods of the training year.

You will have full access to the data I gather from you, and you will be able to respond to developing insights from the analysis of data from all participants.

What will happen to all the data collected on you?

Although the data collected during the pilot study will not be included in the final version of my report, it will still be anonymised, and confidentiality will be assured. Data will be stored in a password protected electronic and locked filing hard copy format during the duration of my research, and will be destroyed once its use for the purposes of the study has ended. Your own data will only be accessed by me.

I have a responsibility to behave ethically at all times, and will follow the British Educational Research Association's Ethical Guidelines.

Suppose you drop out of the study before the end?

This is an entirely voluntary involvement and is not linked in any way to teaching or assessment decisions relating to your subsequent qualification to become a teacher. You may withdraw from part or the whole of the study at any time without giving reasons and will be able to request the destruction of any data you have given us up to that point. It goes without saying however, that I hope you will find it interesting and will continue throughout the project.

What do I need to do now?

Please read through the consent information on the next page. If you choose not to participate you need do nothing more, and I will not contact you again. If, on the other hand, you would like to participate please complete and sign the consent agreement and return it to me at the office.

If you need further information on the conduct of this research please contact my supervisor Dr John Butcher.

Thank you for your consideration of my research project.

Julie Darmody

CONSENT AGREEMENT

Project Title: "Theory versus Practice: Comparing the development of mathematical pedagogical content knowledge of trainees following two routes into Qualified Teacher Status"

I agree to participate in the following aspects of the above project. (Please tick to show agreement)

- ☐ Written questionnaire
- ☐ Face-to-face group interview

I understand that:

- this is related to a larger project, but that by participating in it during my training I am not making any commitment to involvement in later stages;
- both this and the larger project are concerned with finding out more about learning to teach and that I have been fully informed of the aims and purposes of the project;
- there is no compulsion for me to participate in any or all parts of this research. If I choose not to take part, this will not affect my training in any way;
- if I do choose to participate, I may at any stage withdraw my participation. If I choose to withdraw this will not affect my training in any way, and I may request that any data submitted by me up to that date be destroyed;
- any information which I give will be used solely for the purposes of this research which may include publications;
- at the end of the project the information collected may be offered in fully anonymised form to the UK Data Archive;
- confidentiality will be respected by the researcher with regard to the information which I give, including the use of pseudonyms in order to preserve anonymity to the greatest possible extent.

Name:

Address:

Signed:

Date:

Appendix J – Overview of Trainee Participation

Code	Main age phase	Gender	Age group (Over 30) (Under 30)
EBITT 1	EYFS	Female	Over
EBITT 2	KS2	Male	Under
EBITT 3	KS2	Female	Over
EBITT 4	KS1	Female	Over
EBITT 5	KS2	Female	Over
EBITT 6	KS2	Female	Over
EBITT 7	EYFS	Female	Under
EBITT 8	EYFS	Female	Over
EBITT 13	KS2	Female	Over
EBITT 17	EYFS	Female	Over
EBITT 18	KS1	Female	Under
EBITT 19	KS2	Female	Over
PGCE 1	KS1	Female	Under
PGCE 2	KS2	Female	Under
PGCE 3	EYFS	Female	Over
PGCE 4	KS2	Female	Under
PGCE 5	KS2	Male	Over
PGCE 6	KS2	Female	Over
PGCE 7	KS1	Female	Under
PGCE 8	KS2	Female	Under
PGCE 12	KS2	Female	Under
PGCE 13	KS2	Female	Under
PGCE 14	KS2	Female	Under

[illegible]

Appendix L – Example of colour coded lesson observation sheets

Timing	Lesson Commentary – What the Trainee did / How Pupils responded
9:10	KAT on IWB - number lines on wall not 1 can statements
9:13	some children arrive MP recaps for them
9:15	child moves numbers across - bit high for them to reach - post-it notes introduces place holder children all sitting quietly watching MP - counting in 10s - starting at 12 with cat toy & metre stick
9:16	Asked value of 1 in 102 - child answers correctly
9:20	Counting in 100s - silent counting then super slides - asking for number state sentence - Colin (cat toy) sitting in middle of divisions rather than at 10 or 100?
9:20	Modelling multiplying - asking question & answering 100 which asking Ibrahim
9:20	KE takes her group
9:25	MP talks about division TFS discuss Aim says to divide or multiply by 100 you do 2 jumps Ask child to explain 😊 Open question Abid answering - Matten stops him 😞
9:30	Asks children to describe pattern in 10x table and 100x table - Kelly answers - MP says again
9:30	uses ITP - asks child for a number - could child move multiplies by 10 then asks children

Appendix M – Sample of analysis of lesson observation feedback

Route and date	Topic specific pedagogy	Class/behaviour management	General pedagogy	Targets
PGCE LKS2 May	<p>23 comments</p> <p>Starter activity: 4 inverse questions</p> <p>NB went through the 4 inverse questions with the class</p> <p>What kinds of methods have we used for subtraction?</p> <p>Answer column sub, no. line, rounding</p> <p>NB wrote on the board (question recorded by mentor)</p> <p>Which column will I start with? "Last one"</p> <p>Encourage use of H, T, U column</p> <p>Give me another number in hundreds (mentor recorded question)</p> <p>To get a rough answer we can round – e.g. $583 - 396$.</p> <p>What number can we round to? $600 - 400 = 200$</p> <p>Modelled exact answer</p> <p>Children asked to solve one $634 - 216$</p> <p>Class stopped. What do we round to $600 - 200$</p> <p>Went through estimating $510 - 490 = 20$</p> <p>What method would be ideal?</p> <p>Why? Because numbers are close to one another – (mentor recorded counting on method used)</p> <p>$2846 - 1454$</p> <p>$3000 - 100 = 2000$ estimate</p> <p>Yellow and Amber – doing closer number differences</p> <p>Reds – Crossing hundreds/thousands differences</p> <p>NB stopped class and reminded class to estimate first</p> <p>$4381 - 128$ displayed</p>	20	5	<p>1 out of 2</p> <p>Relate plenary to test questions – real life questions where they can use they've learnt.</p>

	<p>What can I round to? What did you round it to? Good question</p> <p>NB modelled column subtraction.</p> <p>Modelled exchanging</p>			
<p>PGCE</p> <p>UKS2</p> <p>June</p>	<p>12</p> <p>Mental starter based around venn diagrams and odd/even numbers</p> <p>Well done for asking children how they knew where the given numbers should be placed rather than just accepting their answers</p> <p>Try asking all the children to place the last few numbers on the venn diagrams drawn on individual white boards</p> <p>The LA children worked with small clocks to read and write time on analogue clocks to the nearest 5 minutes</p> <p>There was a nice balance of practical and written/drawn examples of time</p> <p>The HA children worked on understanding the complex timetables using 24 hour clock</p> <p>C worked with over half the class to teach the reading and interpreting of timetables</p> <p>C asked the children to discuss the importance of timetables and the information that can be gleaned from this</p> <p>Key words already on the working wall were referred to and C had large labels of other key words stuck up as they were introduced.</p> <p>He explained these words and how fitted with the context of timetables.</p> <p>He noted when the children became confused and spent time addressing these misunderstandings.</p>	25	16	No all 3 general pedagogy

	Differentiation was a strength of the lesson. The 4 groups included telling the time, reading a simple timetable with the 12 hour clock, reading a more complex timetable with the 24 hour clock, creating and using a complex timetable with the 24 hour clock. Whilst working with a small group he did extend children's questioning by asking them to explain their reasoning.			
PGCE June UKS2	<p>11</p> <p>Colourful IWB activity – revising coordinates</p> <p>TP used translation – asked for ideas – good</p> <p>Translation explained</p> <p>Examples provided – you modelled examples clearly.</p> <p>Encouraged vocabulary of movement</p> <p>Addressed misconceptions clearly as child translated shapes on IWB</p> <p>Reinforced meaning</p> <p>Modelled correct answer, explaining clearly each step – reinforced coordinates and asked challenging question to HA child</p> <p>Question – how many sq to move to another position?</p> <p>Child asked to give translation for given point on grid</p> <p>Extension – coordinates for 3sq l and 2 sq up</p> <p>Encouraged correct use of vocabulary.</p>	23	8	No all 3 general pedagogy

Appendix N – Overview of Key roles

<p>Mentor Assessor</p> <p>(This person may also assume the role of class teacher)</p>	<p>Formally appointed, by the school, as a mentor for the trainee.</p> <p>An experienced classroom practitioner with at least 3 years teaching experience.</p> <p>Must have received training in supporting trainees, including how to use provider documentation, observing lessons, giving feedback and setting targets.</p> <p>Oversees and facilitates the trainee's timetable for teaching and training during school-based experiences. The trainee may observe the mentor assessor's teaching.</p> <p>Formally observes the trainee on a weekly basis, including recording evidence against the Teachers' Standards and setting targets for development.</p> <p>Has a formal hour-long meeting with the trainee on a weekly basis, in which progress is discussed and targets set.</p> <p>Formally assesses the trainee's evidence base against the Teachers' Standards.</p> <p>Formally reports trainee progress and achievement to the training provider, and attends provider meetings and mentor training sessions as scheduled.</p> <p>Liaises with the class teacher about the trainee's progress and training needs</p>
<p>Class teacher</p> <p>(May also be the mentor assessor)</p>	<p>Selected to work alongside a trainee within their class.</p> <p>Will direct the trainee in specific classroom based teaching and training activities, including working with individuals, groups, team teaching, and whole class teaching.</p> <p>The trainee will observe and reflect upon the class teacher's teaching.</p> <p>May have received training in supporting trainees, including how to use provider documentation, observing lessons, giving feedback and setting targets.</p> <p>Will informally observe the trainee on a daily basis and provide them with feedback</p> <p>May formally observe the trainee and record evidence against the Teachers' Standards</p> <p>Provide information about the needs and abilities of the pupils within the class.</p> <p>Support and monitor, as appropriate, the planning and assessment process so that it meets the needs of the pupils in the class.</p> <p>Provide a daily point of contact for the trainee, delivering on-going support, encouragement and advice.</p> <p>Will liaise with the mentor assessor about the trainee's progress and training needs.</p>
<p>Subject leader in mathematics</p> <p>(May also be mentor and/or class teacher)</p>	<p>Appointed by the school and displays an in-depth knowledge and understanding of the subject knowledge per se and pedagogy of mathematics, across the age range of the school.</p> <p>The trainee may observe the subject leader teaching</p> <p>May have received training in supporting trainees, including how to use provider documentation, observing lessons, giving feedback and setting targets.</p> <p>May formally observe the trainee and record evidence against the Teachers' Standards</p> <p>May be a point of contact for the trainee when seeking advice about planning, teaching and/or assessment</p>
<p>Year group colleagues</p>	<p>May support planning through year group planning meetings, depending on the procedures of the school</p> <p>May provide informal advice and support, as necessary, as usually located within an adjacent classroom.</p> <p>The trainee may observe a range of colleagues, including those in other year groups teaching</p>
<p>Head teacher</p>	<p>Sets the training ethos for the school.</p> <p>May formally observe the trainee and record evidence against the Teachers' Standards</p> <p>Will monitor trainee's progress on a termly basis and ratify the recommendation for QTS.</p>
<p>Visiting Tutor</p>	<p>Employed by the provider.</p> <p>Will observe the trainee on a termly basis, assess their progress against the Teachers' Standards, and monitor and set targets for development.</p> <p>Cross moderates recommendation for Qualified Teacher Status</p> <p>Offers an ongoing point of contact and support for the trainee via the provider's Learning Platform.</p>

Appendix O – Definitions of theory and practice - November

Theory	
Underpinning knowledge of how to teach maths Background pedagogical knowledge such as the theory of conservation How to teach the subject and what strategies to apply How something is done Finding out about resources and methods relating to maths What the children should be learning and how this links to curriculum guidance Discussion, thinking and writing about how things work What has been read about the teaching of maths strategies How children learn maths and they stages they go through Ideas/principles which explain something General rules but it is up to us to apply them Planning of lessons Strategy that has been adopted	Knowledge of how to Mathematical pedagogical content knowledge
Subject knowledge x 3 Mathematical concepts Subject knowledge and understanding Thinking about a subject and understanding it	Knowledge of Subject matter knowledge
Why we do what we do Reasoning behind something Why something is done	Knowledge of why
Books or research Research findings about most effective ways to teach maths Research or thinking behind the subject Historical events – what has happened in experiments What experts/researchers/practitioners say/have written about teaching Research base – educational ideas What academics, books, journals have to say about strategies and how to apply them Reading material – books and online Research element	Research What 'experts' say

Static term – reading and understanding ideas Research related	
Practice	
It is about doing Actual doing/teaching Hands on experience/doing it Applying Learning through experience Actually doing these things within the classroom Doing it physically Hands on Actually teaching Pedagogical knowledge and experimenting with techniques Doing it for yourself and seeing it in real time Hands on practical aspect What happens in the classroom Activities Teaching – working with the children Teaching, planning and assessing Using the resources and methods The lesson itself – what the children are doing and what makes it fun/memorable How it is delivered by a teacher – the skill of teaching How we teach it Teaching the mathematical concepts in a way in which the children will understand and develop	Experience Teaching Doing
Relates to theory Putting theory into action Applying the theory When you apply what academics say about theory	Related to theory Apply theory
Reflecting upon the outcome and making adaptations Reflecting upon the practice	Reflecting and adapting

Appendix P – Trainees’ descriptions of the learning situation which had the biggest impact on their development as a teacher of mathematics in the training year

Teaching a middle set maths group as all of the children were of a similar level	PgCE	Teaching
Teaching time to a year 3 class. I had to adapt my planning several times. I had to experiment with different resources and teaching strategies	PgCE	Teaching and reflecting
Teaching early mathematics daily and reflecting upon my teaching	PgCE	Teaching and reflecting
Team teaching	PgCE	
Planning and teaching a sequence of 5 lessons. Reflection and adaptations	EBITT	Planning, teaching and reflecting
Teaching maths in the outdoor through play	EBITT	Teaching
Interacting with the children as they worked. Address misconceptions and plan next steps	EBITT	Teaching and planning
Second school placement teaching a top set	EBITT	Teaching
Being able to teach from an early point in the year	EBITT	Teaching
Relationships with the pupils – identify misconceptions and resolve. Meet their needs.	EBITT	Teaching
Being observed by my maths coordinator	PgCE	Formal observation
Being observed and acting on feedback	PgCE	
Receiving positive feedback on my own teaching	EBITT	
Observations and feedback on my maths lessons	EBITT	
Refreshing subject knowledge through personal revision and teaching in practice	PgCE	Research and teaching
Seeing shapes in different orientations and understanding the importance of mathematical vocabulary and making lessons interactive so that the child could see shapes in real life situations	EBITT	Theory – pedagogy
Don’t move on unless the basics are secure	EBITT	Reflections. Theory - pedagogy
Working alongside director of maths. Observing, team teaching and then teaching on my own.	EBITT	Teaching, observing and discussions with practitioners
Observing the teaching of maths and putting elements into my own practice	EBITT	Observing and teaching
Meetings with my mentor in maths	EBITT	Discussions with practitioners

Appendix Q – Mentor Questionnaire

Development of Mathematical Pedagogical Knowledge

1. Which training route(s) have you supported trainees on?

GT PGCE

2. Please rate the level of impact (with 5 being the highest level of impact) you believe the following has on trainee development of mathematical pedagogical knowledge

	1 (no impact)	2	3	4	5 (High impact)
Their own experience of learning maths at school					
Their own experience of teaching maths prior to the start of the course					
Centre-based training					
Private research and reading					
Observation of good practice					
Discussions with practitioners including mentor, class teacher and/or maths subject coordinator					
Discussions with other trainees about maths					
Feedback from observations of their teaching of maths					
Their own reflections on their teaching of maths					
Practical experience of planning, teaching and assessing in maths					

3. What do you expect trainees to gain from centre-based training in maths?
4. What is the role of school-based practice in developing mathematical pedagogical knowledge?
5. What is the inter-relationship between centre and school based practice?
6. Describe your role in this process.

If you have worked with trainees across both routes (PGCE and GT) please answer the following 2 questions.

7. Is there a difference between how GT trainees develop their knowledge compared with PGCE trainees?
8. Do you consider trainees from one particular route to be more confident/prepared for the NQT year by the end of the course? Why do you think this ?

Appendix R – Overview of mathematics role in school prior to the EBITT training year

Role in school prior to the course <i>“What was your role in school prior to the start of this course?”</i>	Pre-course role in mathematics <i>“Describe the ways in which you were involved in the teaching of maths within this role?”</i>
Teaching assistant and Higher Level Teaching Assistant (HLTA)	Assisted class teachers every day and covered classes in their absence using lesson plans
Unqualified teacher	Limited as in middle school so breadth of subjects was limited
Unqualified teacher	Independent teaching and planning
HLTA	Planned and taught lessons to year 2 SEN group (8 children) for 3 years
Unqualified teacher	Planned and taught maths
Unqualified teacher	Responsible for planning for long and medium and short terms, as well as teaching and assessment
Teaching assistant	Supporting in class. Intervention groups for different abilities
Unqualified teacher	Taught using own planning based on a published scheme
Teaching assistant	Covering lessons and intervention groups
Nursery nurse	Supported children in child initiated learning within mathematics
Teaching assistant	Supporting SEN children and some small group teaching
Nursery nurse	Whole class or small group teaching
Teaching assistant	Teaching oral/mental starters. Some cover for lessons
Nursery nurse	Supporting children in maths tasks and recording assessments and observations
Teaching assistant	Supporting a statemented child in maths